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ART. XLI.—*On the Deportment of Charcoal with the Halogens, Nitrogen, Sulphur, and Oxygen;* by W. G. MIXTER.

Charcoal containing the Halogens.

THE difficulty in obtaining amorphous carbon fairly pure is a serious obstacle in an investigation of its properties. Kirwan* observed in the year 1785 that charcoal after prolonged and intense ignition contains hydrogen. The recent handbooks and dictionaries of chemistry state that the hydrogen may be removed by heating the charcoal in chlorine, while the older dictionaries contain nothing on the subject. The writer has been unable to learn who is the author of the method or to find any mention of analytical tests for chlorine in charcoal purified by ignition in chlorine. Berthelot and Petit† treated wood charcoal with hydrofluoric and hydrochloric acids, next with chlorine at a red heat, and finally calcined it in a Perrot furnace. Their charcoal was doubtless free from chlorine. Weber‡ for his work on the specific heat of carbon prepared amorphous carbon by heating wood charcoal to bright redness for fifteen minutes in a stream of chlorine in order to remove hydrogen. It would be interesting to know that the distinguished experimenter proved the absence of chlorine in the charcoal he used. Wright and Luff§ heated sugar charcoal for two hours in chlorine and then ignited it for six hours in platinum over a blowpipe to remove chlorine. Their analyses of two preparations are as follows:

* Kopp, Geschichte der Chemie, iii, 289.
† Bulletin, 1889, ii, 90.
‡ Phil. Mag., IV, xlix, 161, 276.
§ Jour. Chem. Soc., xxxiii, 17.

Carbon	96·17	95·13
Hydrogen	0·84	0·75
Ash	1·56	1·68
Oxygen by difference	1·43	2·44

These results are interesting as they show how tenaciously charcoal retains hydrogen even after ignition in chlorine.

While attempting to prepare for use in an investigation amorphous carbon free from hydrogen the writer observed that charcoal retains considerable chlorine at high temperatures. This fact has doubtless been observed but there appears to be nothing on the subject in the literature of chemistry except the statement by Schönbein* that charcoal absorbs chlorine and retains some of it when heated.

Experiments were made with amorphous carbon from various sources, but only the results will be given that were obtained with three varieties, viz: sugar charcoal, lampblack, which is finely divided charcoal, and gas carbon. The first was prepared by charring in an open platinum dish cane sugar which was almost free from ash. The charcoal was pulverized in an agate mortar, moistened with sugar syrup and then pressed in a hydraulic press. The pieces were next heated to redness and plunged into a thick syrup, and this treatment was repeated until the charcoal would sink in water without boiling to expel the air from the still porous coal. Finally, the sugar charcoal was heated intensely for several hours in a crucible by a charcoal fire in a wind furnace having a strong draught. The method employed for estimating hydrogen was as follows: the charcoal was heated to redness in a platinum tray, allowed to cool in a desiccator, then weighed and placed in the combustion tube and then, in order to drive off absorbed water, it was heated to faint redness for half an hour in a current of dry air in which it did not ignite. The combustion was made in oxygen dried by oil of vitriol, solid caustic potash, and finally, calcium chloride. An ordinary calcium chloride tube was used to absorb the water of the combustion. In a blank test of the apparatus the calcium chloride tube gained 0·2 milligram. One lot of sugar charcoal prepared as described yielded 0·13 per cent of hydrogen, 1·12 gram being used for the combustion. 1·25 gram of another preparation gave 0·126 per cent of hydrogen and 0·04 per cent of ash. The sugar charcoal burned with difficulty in oxygen, was hard enough to scratch glass, and was a good conductor of electricity.

The lampblack used was of a kind made from natural gas known as "Diamond Black." It is well described by Mallet.†

* Pogg. Ann, lxxiii, 326. † Chem. News, xxxviii, 94.

My analysis of the lampblack gave 1 per cent of hydrogen, 0·04 of ash and in an air-dry portion 0·23 per cent of nitrogen by the absolute method. After igniting for two hours in dry nitrogen and allowing to cool in the gas, no nitrogen was obtained on burning with oxide of copper. This kind of lampblack when pressed into compact pieces conducts electricity, and when heated *in vacuo* it yields a small sublimate as observed by Mallet.

The gas carbon used was from the inner portion of a thick piece. A combustion of 1·742 gram of it yielded 0·035 per cent of hydrogen and 0·88 of ash.

The chlorine used in the experiments was made from salt, manganese dioxide and sulphuric acid, and was passed through one wash-bottle containing water and one containing oil of vitriol. The temperature in the experiments was the highest attainable in a gas combustion-furnace, that is, a bright red heat. A hard glass or porcelain tube was used to hold the charcoal during the ignition in chlorine.

Experiment 1.—10 grams of sugar charcoal were ignited in chlorine for three hours, then left for a day over solid caustic potash, and finally heated to redness for an hour *in vacuo*. The product weighed 10·304 grams and contained 3·7 per cent of chlorine.*

Another portion of 10 grams of the same charcoal was exposed at common temperature to a current of chlorine for three hours, then dry air was passed through the tube for 15 minutes. The gain in weight of the charcoal was 0·098 gram which was not diminished by exhausting the tube and then opening to the air. The results show that cold dense sugar charcoal takes up much less chlorine than when heated. Probably chlorine is simply occluded by cold charcoal; whether chlorine is chemically combined which is retained by hot charcoal will be discussed after the experimental results are given.

Experiment 2.—Sugar charcoal was heated to redness in a porcelain tube, then chlorine was passed through the tube for three hours, and while red hot the chlorine gas was displaced by nitrogen. The charcoal as it came from the warm tube gave off no chlorine, of which it was found to contain 4·6 per cent.

Experiment 3.—(*a*) Chlorine was passed for two hours over cold lampblack, and then (*b*) over glowing lampblack. Both preparations of chlorinated lampblack were left for a day over solid potash in a partial vacuum. 7·9 per cent of chlorine

* The estimation was made by burning the chlorinated charcoal in moist oxygen and passing the products of combustion through dilute ammonia to absorb the chlorine, which was afterwards precipitated as silver chloride by the addition of silver nitrate and nitric acid It was found that chlorinated charcoal or lampblack burned with difficulty and often incompletely in dry oxygen.

was found in first. The preparation *b* gave 14·3 per cent of chlorine by the combustion method and 15·5 per cent by fusing with soda and niter. The low result by the method of combustion is due to the formation of carbon chlorides which form a slight sublimate and sometimes oily drops on the ammonia water. 3·75 grams of the chlorinated lampblack of *b* were placed in a glass tube, the anterior end of which contained lumps of caustic potash, and the air was exhausted by a Sprengel pump. The part of the tube containing the lampblack was heated to redness for two hours while the exhaustion was maintained by constant pumping. The evolution of gas not absorbed by potash was slow and 22^{cc} were obtained. The gas had a slight odor and burned with a blue flame. The lampblack after heating *in vacuo* contained 8·5 per cent of chlorine.

Experiment 4.—Lampblack in compact pieces* was heated in a current of chlorine for four hours in a porcelain tube to the highest temperature of a gas combustion furnace. The product after standing a day in the air contained 11·9 per cent of chlorine. 10 grams of the chlorinated lampblack were next placed in a porcelain tube which was connected with a tube containing calcium chloride and slaked lime to absorb water, chlorine and carbon dioxide. The air in the tube was pumped out so completely that after nine hours no more air was obtained by further pumping. The tube was then heated to bright redness for three hours while the Sprengel pump was in constant action. 30^{cc} of a gas were obtained which had a slight odor and burned with a blue flame. The chlorinated lampblack after ignition *in vacuo* contained 9·04 per cent of chlorine.

Experiment 7.—The lampblack of the preceding experiment with 9·04 per cent of chlorine was placed in a porcelain tube plugged with asbestos, and the sugar charcoal of experiment *2* containing 4·6 per cent of chlorine was put into a covered porcelain crucible. Both were heated in a covered clay crucible in a coal fire for fifteen hours, much of the time to a white heat. The porcelain was softened. No chlorine was detected in either carbon after the ignition. The test was made by cautiously heating the carbon with soda to which niter was gradually added and then testing for chlorine by the usual method. The ash of the sugar charcoal increased from 0·04 to 0·17 per cent, due undoubtedly to the absorption of vapors,

* The lampblack was obtained in compact form by subjecting it to a pressure of about 2500 pounds to the square inch in a hydraulic press. Pressed lampblack is one of the best forms of charcoal for many kinds of experiments as it is uniformly porous and consists of very minute particles. That used in the experiments sank slowly in water, that is, its apparent density was 1 while the true density was according to Mallet 1·7.

perhaps chlorides, during the intense ignition. The following is the analysis of dechlorinated sugar charcoal for hydrogen: 1·4964 grams of the carbon which had been heated to dull redness and cooled in a desiccator were placed in a combustion tube and then heated again to dull redness while a slow current of dry air was passing through the tube to expel if possible all water. The carbon did not appear to burn. The chloride of calcium tube was then attached and the combination made with oxygen. 0·073 per cent of hydrogen was obtained. Another determination with 1·089 gram not heated until placed in the combustion tube gave 0·065 per cent.

Experiment 8.—Gas carbon in lumps was ignited in chlorine and then was allowed to cool in a current of dry nitrogen. Two tests failed to reveal any chlorine in the gas carbon thus treated. Finely pulverized gas carbon was also found to take up no chlorine at a red heat.

As gas carbon does not combine with chlorine the question was suggested: Will charcoal from which chlorine has been expelled by heat take up chlorine again? The following results show that it will.

Experiment 9. — The dechlorinated sugar charcoal of *7* was found to contain 3·24 per cent and the dechlorinated lampblack 2·82 per cent of chlorine after ignition in chlorine.

Experiment 10.—Lampblack and sugar charcoal were ignited for two hours in dry hydrochloric acid gas, and while hot the gas was displaced by dry air. The lampblack contained a minute trace and the sugar charcoal 0·26 per cent of chlorine.

Experiment 11.—Dry hydrogen was passed over the compact chlorinated lampblack of *4* At ordinary temperature no hydrochloric acid appeared, while at a temperature a little below redness the acid came off for three hours, and at a red heat more acid came off. A test showed that the charcoal still contained a little chlorine.

Experiment 12.—Lampblack and sugar charcoal were ignited for two and a half hours in bromine vapor which was finally displaced from the hot tube by a current of dry air. The lampblack was found to contain 3·04 per cent of bromine, and after exposure *in vacuo* to a red heat for two hours it contained 1·49 per cent of bromine. The sugar charcoal absorbed only 0 25 per cent of bromine, most of which it lost on ignition *in vacuo.*

Experiment 13.—This experiment was conducted like the preceding, iodine being used. The lampblack contained 2·04 and the sugar charcoal 0·63 per cent of iodine, both preparations retaining but a trace of iodine after ignition for three hours *in vacuo.*

Experiment 14.—9·6 grams of lampblack were chlorinated by heating for an hour in chlorine, and then allowed to cool in a current of gas. After standing for a day the product was burned in a current of dry oxygen. In the cool and narrowed part of the combustion tube a slight sublimate formed not sufficient for a quantitative analysis. It was found to contain chlorine and to burn with a smoky flame. The gaseous products of the combustion were passed through dilute ammonia on which a slight oily product collected. There was a little loss of chlorine in the fume which escaped from the ammonia which was found to contain, after the combustion was finished, 2·638 grams of chlorine, showing that the lampblack had taken up 27 per cent of its weight of chlorine.

Experiment 15.—Native graphite was ignited for two hours in chlorine, which was then displaced while hot by air. The graphite retained but a trace of chlorine, owing doubtless to impurities.

Experiment 16.—Half a gram of fragments of white diamonds remained unchanged in weight after ignition in chlorine for an hour.

Chloroform, benzene, alcohol and ether failed to dissolve anything from chlorinated lampblack. Boiling dilute ammonia water removed a little chlorine, but the lampblack after protracted digestion with ammonia retained chlorine. A portion of the chlorinated lampblack of *3* which had been heated *in vacuo* and contained 8·5 per cent of chlorine was mixed intimately with artificial alumina. The mixture gave no sublimate on heating in a glass tube in the blast lamp. The test was repeated with a new mixture and the tube containing it was heated in a combustion furnace for half an hour. No sublimate formed, but on passing chlorine over the mixture aluminum chloride appeared at once and was rapidly deposited in the cool part of the tube. Gas carbon, alumina and chlorine yielded at a red heat only slowly a small quantity of aluminum chloride.

The foregoing experiments were made to find whether chlorine held by charcoal at high temperatures is occluded, that is condensed in the pores and on the surface or is chemically combined with the carbon. It is not probable that the chlorine is occluded since gases condensed by charcoal are given off *in vacuo* on heating. If the chlorine were occluded then we should expect that bromine and iodine would be held in larger quantity by charcoal, as the more readily condensible gases are absorbed in the largest quantity, but glowing charcoal retains less bromine than chlorine and still less iodine. Charcoal facilitates combination of gases but when hydrogen

is passed over hot chlorinated charcoal hydrochloric acid, which is not retained by hot charcoal, is formed very slowly. Assuming that chlorine combines chemically with glowing charcoal, the question is, Does the chlorine unite directly with the carbon? Berzelius* stated, "In wasserfrei Chlorgas wird ein wohlausgeglühte Kohle bei keine Temperatur verändert." Nothing was said about testing the charcoal for chlorine. Recent writers state that carbon and chlorine do not unite directly, and the foregoing results with the diamond, graphite and gas carbon are in accord with this view. Chlorine, however, combines at high temperatures with charcoal which is not pure carbon but contains hydrogen and the latter is apparently replaced by chlorine in the chlorination of charcoal. Gas carbon containing 0·035 per cent of hydrogen does not take up chlorine, while sugar charcoal with 0·07 per cent of hydrogen does. Further experiments are necessary in order to determine whether sugar charcoal and gas carbon with a like content of hydrogen differ in their deportment towards chlorine.

Nitrogenous Charcoal.

Animal charcoal is known to contain nitrogen and to yield cyanogen to molten alkalies but the amount is not given, although doubtless known to manufacturers of animal charcoal and cyanides. It is stated on page 365 of this Journal that lampblack retains no nitrogen after ignition in dry nitrogen. This accords with the accepted fact that charcoal does not combine at high temperature with free nitrogen. The results of the following experiments show that charcoal not only retains nitrogen at very high temperatures when once combined with it, but also fixes it when ignited in an atmosphere of compounds of it such as ammonia and the oxides of nitrogen. In the decomposition of these bodies by glowing charcoal the nitrogen may be regarded as in the nascent state. The lampblack used in the tests was the "Diamond Black" variety described on page 364 of this Journal.

Experiment 1.—Lampblack was heated to redness for an hour and a half in dry ammonia gas, and while the tube was hot the ammonia was displaced by dry nitrogen. The product contained 3·17 per cent of nitrogen. On heating the nitrogenous lampblack for half an hour to a red heat *in vacuo* some ammonia came off owing to hygroscopic moisture, and the percentage of nitrogen fell to 2·68 per cent.

Experiment 2.—Hard-pressed lampblack was heated for an hour to the highest heat of a gas combustion furnace in a porcelain tube through which dry ammonia gas was passed. The

* Lehrbuch des Chemie, 1843, i, 301.

ammonia was displaced by dry nitrogen and the tube was exhausted. The product contained 2·22 per cent of nitrogen. In this and the preceding experiment considerable hydrogen was set free from the ammonia.

Experiment 3 was a repetition of *2* with the difference that the ignition in ammonia was maintained two hours. The escaping gases contained cyanogen. The lampblack contained 3·18 per cent of nitrogen.

Experiment 4.—Sugar charcoal, containing 0·126 per cent of hydrogen and 0·04 per cent of ash, was heated to a bright red heat and dry ammonia was passed over it for an hour, and then the ammonia was displaced by nitrogen and the tube allowed to cool. The hydrogen set free was collected over water and tested by burning. The charcoal after ignition in ammonia yielded 0·16 per cent of nitrogen on combustion. A portion of it was heated with sodium carbonate until it disappeared, the fused mass was dissolved in water and a mixture of ferrous and ferric chloride was added and the whole was warmed and then cooled. On acidifying with hydrochloric acid a small amount of prussian blue appeared.

As incandescent charcoal and ammonia react to form cyanogen it may be that the last is the compound taken up by the charcoal in the experiments with ammonia, since cyanogen reacts with charcoal producing a nitrogenous coal as shown by the following:

Experiment 5.—Pressed lampblack was placed in one end of a tube and mercuric cyanide in the other end, and the tube was gently heated while dry air was passed through it to remove moisture. Next the lampblack was heated to a red-heat which was sufficient to decompose paracyanogen, and the mercuric cyanide was gradually heated so that cyanogen gas passed for half an hour over the lampblack which was then allowed to cool in the gas. The lampblack was next heated, but not to redness, for half an hour in an exhausted tube to remove occluded cyanogen. Gas ceased to come off toward the end of the heating *in vacuo*. The product contained 6·48 per cent of nitrogen. It was finally heated *in vacuo* for one hour to redness when it gave off but little gas and no cyanogen. After the second heating *in vacuo* the lampblack was found to contain 6·46 per cent of nitrogen. When it was ignited in steam, ammonia was formed abundantly.

Experiment 6.—Animal charcoal of unknown origin but presumably from blood, as it left after burning only a small amount of red ash, was heated to redness in a covered platinum crucible, and then was found to contain 6·82 per cent of nitrogen.

Experiment 7.—Albumin from blood was charred in a covered platinum crucible, and the residue was exposed to the heat of a blast lamp five minutes after the escaping gases ceased to burn. The charcoal, which was very bulky and soft, contained 4·43 per cent of nitrogen. It gave off ammonia when heated in steam. A portion of the charcoal after heating for three quarters of an hour to the melting point of cast iron gave a distinct reaction for nitrogen by the test with molten sodium carbonate, etc.

Experiment 8.—Carefully washed and dried egg albumin charred as above yielded a charcoal containing 4·61 per cent of nitrogen.

In experiments described hereafter the charcoal used was not strongly heated and was made by charring sugar in a large platinum dish heated by a Bunsen burner.

Experiment 9.—10 grams of sugar charcoal were heated in a glass tube for a time to faint redness and then to the highest heat of a combustion furnace. During the heating 7 liters of pure nitric oxide* were passed over the charcoal. The charcoal did not glow as when burning rapidly, and about one-third of it was consumed. Carbonic oxide came off abundantly and with it small quantities of carbon dioxide, ammonia, and cyanogen. The charcoal after cooling was pulverized and then heated to incipient redness *in vacuo*. Thus treated it contained 3·44 per cent of nitrogen, but after heating for an hour in a Perrot furnace it was free from nitrogen. The complete removal of the nitrogen was doubtless due to the action of vapor of water from the burning of the gas.

Experiment 10.—This was conducted as nearly as possible like the preceding experiment with the exception that pure nitrous oxide was used. The product contained 1·09 per cent of nitrogen.

Experiment 11.—This was a duplicate of Exp. 10, with the difference that the charcoal was allowed to cool in dry carbon dioxide after the combustion in nitrous oxide was stopped. 3·85 per cent of nitrogen was found in the product. A part of this nitrogenous charcoal was heated for an hour to the highest temperature of a Perrot furnace. The charcoal was held in the middle of a porcelain tube by plugs of asbestos, and lower end of the tube which was not heated contained calcium chloride to dry the air in the tube. The charcoal after exposure to the intense heat was found by the absolute method to contain 0·46 per cent of nitrogen. The charcoal was also further tested by heating with sodium carbonate, dis-

* The nitric oxide used in this and subsequent experiments was made from nitric acid by means of ferrous sulphate and was dried by sulphuric acid.

solving the saline mass in water and then adding successively a solution of ferrous-ferric chloride and hydrochloric acid. The prussian blue reaction showed the presence of more than a trace of nitrogen.

Experiment 12.—17 liters of nitric oxide were passed during an hour and a half through a tube containing 20 grams of charcoal heated to a dull red. 8 grams of charcoal were burned. The charcoal in the posterior end of the tube glowed feebly and mostly disappeared and the small portion remaining unburned contained 15·33 per cent of nitrogen, while the charcoal in the anterior end contained only 0·96 per cent. 0·092 gram of ammonia was obtained by passing the gases of the combustion through hydrochloric acid.

Experiment 13.—This was made as nearly as possible like the preceding, nitrous oxide being used. The charcoal burned more rapidly than in nitric oxide and with a yellow flame, disappearing completely in the posterior end of the tube. When, however, the heat was lowered to a faint red a small portion of unburned charcoal next the current of gas remained which contained 3·39 per cent of nitrogen, the charcoal from the anterior end yielding 0·26 per cent. The total amount of ammonia collected in the gaseous products of the combustion was 4 milligrams. When the nitrogenous charcoal of this experiment was heated in steam ammonia was formed.

Experiment 14.—30 grams of charcoal were kept at a dull red heat for three hours while 50 liters of nitric oxide were passed over it. The gas was dried by sulphuric acid in three wash bottles. The small portion of charcoal which remained in the posterior end of the tube contained 13·79 per cent of nitrogen. The nitrogen was not estimated in the remainder of the coal which was found to yield cyanogen to a hot concentrated solution of potassium hydroxide.

The charcoal used in the foregoing experiments contained considerable hydrogen and oxygen, when, however, charcoal nearly free from hydrogen is partly burned in nitric oxide no nitrogen is retained as the following shows:

Experiment 15. — Charcoal containing 0·126 per cent of hydrogen and no nitrogen was used. 10·5 grams of dense pieces were heated in a tube from which the air was displaced by dry carbon dioxide. 17 liters of nitric oxide dried by sulphuric acid in three bottles were passed over it in 35 minutes and the highest temperature of a combustion furnace was maintained. 3·7 grams of the coal were burned, the piece in the posterior end of the tube falling to a powder, which was found by the following test to contain no nitrogen: 0·2647 gram of the charcoal and 1·3 gram of potassium chlorate inti-

mately mixed with freshly ignited copper oxide were placed in a combustion tube, and then copper oxide, a long roll of bright copper gauze and hydrogen sodium carbonate were put in. The tube was exhausted by a mercury pump and the combustion was made as usual in the absolute method. 0·2^{cc} of gas was collected, the amount repeatedly obtained in blank tests. This method was employed in all the estimations of nitrogen in charcoal, experience having shown that it is difficult to burn charcoal with copper oxide alone, and that it is better to mix the coal with 5 parts of chlorate than to place the latter in the end of the tube. In none of the determinations of nitrogen was the copper gauze perceptibly oxidized.

Experiment 16.—Uric acid was heated in a covered platinum crucible over a large gas burner as long as combustible gases came off. The resulting charcoal contained 34·06 per cent of nitrogen.

Experiment 17.—Uric acid was charred by heating gradually at first, then for half an hour to the highest temperature of a Perrot furnace. The charcoal after this intense ignition yielded 3·52 per cent of nitrogen.

Experiment 18.—Uric acid contained in a covered platinum crucible was heated gradually and the charcoal formed was kept at a dull ret heat for 15 minutes after the escaping gases ceased to burn. This product had 39·62 per cent of nitrogen. It was an exceedingly bulky black powder which gave off ammonium cyanide when heated in a current of dry hydrogen.

Experiment 19.—1 gram of paracyanogen left 6 milligrams of black residue after heating for two minutes in a covered platinum crucible over the same lamp that was used in *16*.

Nitrogenous charcoal which has been intensely heated does not contain paracyanogen as this is converted into gaseous cyanogen by heat. It is possible that the charcoal from uric acid with the large content of nitrogen is composed in part of paracyanogen.

Charcoal containing Sulphur.

Berzelius* made the following statement regarding a solid sulphide of carbon: "Die Kohle, welche zur Darstellung dieser Verbindung (carbon disulphide) angewandt worden ist, enthält Schwefel in chemischer Verbindung, der nicht durch Glühen ausgetrieben werden kann, wenn dabei der Zutritt der Luft verhindert wird." This fact, not mentioned in recent works on chemistry, must be familiar to manufacturers of carbon disul-

* Lehrbuch der Chemie, 1843, i, 300.

phide. Solid compounds of carbon and sulphur formulated as $CS \cdot C_2S_3$, and C_2S_5 have, however, been described.

Experiment 1.—30·9 grams of air dry soft sugar charcoal were kept at the highest temperature of a combustion furnace for an hour and a half, and during this time the vapor of 30 grams of sulphur was brought into contact with it. No sulphur passed unchanged over the charcoal but hydrogen sulphide came off abundantly during the first half of the time of heating. When all the sulphur had been distilled from the end of the tube containing it dry hydrogen was passed in and hydrogen sulphide was again formed. The charcoal after cooling in a current of hydrogen weighed 30·1 grams and contained according to two estimations 20·02 and 19·95 per cent of sulphur. The sulphurized charcoal gave up no sulphur when treated for five minutes with a boiling solution of potassium hydroxide having a density of 1·5. The charcoal sank in the solution and hence had a density higher than 1·5. A portion of the charcoal gave off at the heat of a combustion furnace a little hydrogen sulphide and sulphur but no carbon disulphide, while another portion gave off the last at a bright red heat in a Perrot furnace. A third portion of the sulphurized charcoal was placed in a porcelain crucible surrounded by sugar charcoal in a clay crucible and was heated to the highest temperature of a Perrot furnace which melted cast iron readily. The charcoal after the intense ignition retained 3·4 per cent of sulphur. It was free from ash and, when burned in a current of moist oxygen in a combustion furnace, left a small amorphous black coal which disappeared when the tray holding it was heated over a blast lamp.

Experiment 2.—Vapor of carbon disulphide was passed for an hour over soft sugar charcoal at a red heat. The carbon disulphide was displaced by dry hydrogen in which the charcoal was allowed to cool. Hydrogen sulphide was formed abundantly at first, while during the latter part of the time of heating but little was detected. The charcoal sulphurized by carbon disulphide was found to contain 11·14 per cent of sulphur.

Experiment 3.—1·2632 gram of sugar charcoal containing 0·126 per cent of hydrogen and 0·04 per cent of ash was exposed for twenty minutes to sulphur vapor at the highest heat of a gas combustion furnace and then was allowed to cool in a current of dry hydrogen. The charcoal lost 0·0055 gram in weight and was found to be free from sulphur.

Experiment 4.—Charcoal such as used in the preceding test was subjected to sulphur vapor at the temperature of a Perrot furnace. It was next heated to redness in a crucible to drive

off occluded sulphur and was then found to contain 0·29 per cent of sulphur. Carbon disulphide was not produced in this experiment nor was it likely to be formed since the temperature of the furnace was sufficient to decompose it as was proved experimentally.

Experiment 5. — Filter paper nearly free from ash was charred at a dull red heat in vapor of sulphur and the latter was displaced by hydrogen. The product contained 29·1 per cent of sulphur.

Experiment 6.—Filter paper in loose rolls was placed in a large glass tube and was then wet with a saturated solution of sulphur in carbon disulphide. The latter was driven off and a considerable quantity of solution of sulphur was poured into the tube. After the carbon disulphide was expelled from the tube again the paper was charred by gradually heating to incipient redness, and dry hydrogen was passed through the tube during the heating and cooling. Two estimations of sulphur in the charcoal gave 46·46 and 46·60 per cent. This sulphurized charcoal yielded nothing to boiling carbon disulphide and gave up no sulphur to a boiling solution of potassium hydroxide.

Experiment 7.—This was made as nearly as possible like the preceding. The product contained 43·64 per cent of sulphur and exhibited the same negative deportment towards carbon disulphide and potassium hydroxide.

The results show that nearly pure amorphous carbon takes up but little sulphur, while a soft charcoal containing much hydrogen and oxygen takes up considerable even from carbon disulphide. The sulphur is chemically combined as Berzelius held, for it is not removed by solvents even from charcoal which is nearly one half sulphur.

Combustion of Charcoal in Oxygen.

The paper by H. B. Baker* on combustion in dry oxygen suggested a lecture experiment to show that charcoal will not burn in dry oxygen as readily as it does in the gas containing water. For this purpose Hoffman's experiment† was modified by allowing the oxygen in the apparatus shown in fig. 1, to dry for a day or longer by contact with phosphorous pentoxide contained in a short tube just below the bulb. The charcoal was hung on the small wire above the spoon and was intensely heated, cooled in carbon dioxide and then placed in the apparatus. To carry out the experiment the wire was heated by electricity until the charcoal was glowing at the point of con-

* Jour. Chem. Soc., xlvii, 349.

† Berichte der deutsch. chem. Gesellsch., ii, 251.

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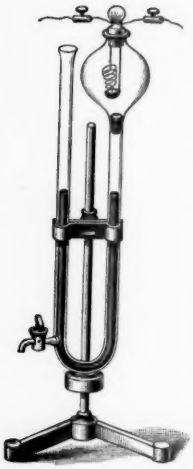


tact with the wire. In many of the trials the charcoal ceased to glow as soon as the current of electricity was stopped, burning readily, however, when ignited in moist oxygen. The failures in the experiments led to an investigation of the burning of charcoal. Baker* in his experiment used charcoal previously ignited in chlorine. Such charcoal contains chlorine unless heated for a long time to a white heat,† and the writer has frequently observed that chlorinated charcoal only partly burns at the temperature of a combustion furnace in oxygen dried as for organic analyses, and that after the coal has ceased to glow it ignites again on admitting moist oxygen and burns completely. Dubrunfaut‡ failed to burn sugar charcoal mixed with copper oxide in a current of dry oxygen. Other chemists have alluded to the difficulty attending combustions in dry oxygen; Dumas,§ however burned graphite in oxygen dried by solid caustic potash and sulphuric acid.

A Hoffmann apparatus, such as shown in fig. 1, was used in the investigation. It held about 350^{cc} of gas and had heavy platinum wires passing through the stopper to the small wire which held the charcoal. To prepare it for use sufficient mercury was poured in to fill the tube at the bend below the stopcock and a short wide tube containing phosphorous pentoxide was placed in the neck below the bulb which was then closed. Next the charcoal and all the platinum below the stopper were heated in a blast lamp. The charcoal used in *1*, *2*, *3* and *4*, was allowed to cool in carbon dioxide, but the sugar charcoal of the other experiments was put into the apparatus while glowing as it did not burn in air. The apparatus was then filled with oxygen by passing through it about two liters of the gas dried as for organic analyses. In *1*, *2*, *3* and *4*, the supporting wire passed through a hole in the charcoal, thus giving only one point of contact, in the other experiments it was placed in an inverted cone of platinum wire.

Experiment 1.—0·033 gram of dense wood charcoal previously heated to redness for an hour was taken, and the gas was allowed to dry a day. The charcoal ignited when heated by a current of electricity through the wire and burned completely without further heating. The volume of the gas at

* Loc. cit.
‡ Comp. rend., lxxiii, 1395.
† This Journal, p. 364.
§ Comp. rend., lxxiv, 137.

the temperature of the room, which was constant, was 1·8^{cc} greater than before the combustion.

Experiment 2.—0·0337 gram of same charcoal as used in *1*, gave the same results, except that the volume of gas increased 2·4^{cc}.

Experiment 3.—Another lot of hard burned charcoal was tried in gas dried for a day. Three times the coal failed to burn after it had been heated at one point to incandescence, burning, however, brilliantly when ignited by prolonged heating.

Experiment 4.—The charcoal from the same piece as used in *3*, did not burn when first heated to redness at one point but when heated a second time it burned well.

Experiment 5.—Dense sugar charcoal containing 0·126 per cent of hydrogen ignited promptly when the wire cone holding it was heated, and burned brilliantly and completely in oxygen which had been in contact with phosphorus pentoxide thirteen days.

For the remaining experiments with the Hoffmann apparatus the sugar charcoal described on page 366 was used. It contained 0·07 per cent of hydrogen and 0·17 per cent of ash. The amount weighed off for each trial was 0·04 gram, which was somewhat reduced by heating as already described. The gas was allowed to dry for two days in each case.

Experiment 6.—The charcoal did not burn after it was heated to faint redness, but when heated hotter it continued to burn after the current from the battery was broken. The volume of the gas increased 1·5^{cc}.

Experiment 7.—The charcoal after it was first ignited burned a few seconds. Ignited a second time it partly burned, and it did not burn completely until it was heated intensely. The volume of the gas was 2^{cc} greater than before the combustion.

Experiment 8.—The charcoal burned completely after the battery current was broken. In this and the following tests the apparatus stood in a cylinder of water having the temperature of the room. The pressure of the gas when it had attained the temperature of the water was 2·4^{mm} of mercury greater than before the combustion.

Experiment 9.—The result was the same as in *8*, except that the pressure increased 2^{mm}.

Experiment 10.—The charcoal was heated gradually until it was ignited. The pressure increased 3^{mm}.

Experiment 11.—The charcoal ceased to burn after the first heating by the hot wire and when ignited again it burned completely. The pressure increased 2^{mm}.

The increased volume of gas after a combustion can only be explained on the assumption that some carbonic oxide was

formed, although the oxygen largely exceeded the amount required for the complete oxidation of the carbon. To prove that the increase was not due to heating the wires passing the stopper, the wires were repeatedly heated by an electric current and the gas in all cases returned on cooling to its original volume. Nor could any air have passed in by the stopper for the pressure in the apparatus was greater during the combustions than that of the atmosphere.

The above results throw no light on the question of the burning amorphous carbon in dry oxygen, as charcoal containing 0·07 per cent of hydrogen and upwards was used, which would yield water. It is evident, however, that dense charcoal must be intensely heated before it will burn in dry oxygen. When such charcoal ceases to burn after having been ignited at one point it may be that the temperature of the part burning falls below the point of ignition owing to the dense coal conducting heat from it. Charcoal even of the densest variety when burning rapidly in oxygen is surrounded by a small flame which may be due in part to the incandescence of carbon dioxide and oxygen about the piece, but the flame is chiefly that of burning carbonic oxide, which formed in the reaction between the oxygen and glowing carbon, as the latter is in excess in the limited space where the reaction occurs. Carbonic oxide is formed either by the direct union of oxygen with carbon or by the reduction of carbon dioxide. Carbonic oxide, as Meyer* has shown, burns when mixed with dry oxygen only when intensely heated by a powerful electric discharge, and carbonic oxide mixed with air or with an excess of oxygen not dried burns with difficulty and ignites only at a high temperature. In order then that charcoal may continue to burn in oxygen the temperature must be maintained sufficiently high to ignite the carbonic oxide. Rapid combustion will do this while slow combustion will not, as the following results show:

Experiment 12.—A piece a centimeter thick of dense charcoal having 0·126 per cent of hydrogen was placed in a glass tube and a rapid current of oxygen was passed in, the gas being dried as for organic analysis. The charcoal was heated by one burner until it began to glow. It then rapidly became hotter and in a few seconds there was a slight puff, flame passing 20 or 30 centimeters through the tube, after which the charcoal burned brilliantly with a slight flame surrounding it. This result has been attained many times, not, however, without failures.

Experiment 13.—A piece of dense wood charcoal a centimeter thick and three centimeters long when heated in a rapid

* Berichte der deutsch. chem. Gesellsch., xix, 1099.

current of moist oxygen commenced to burn without any puff. It was allowed to cool until black on the outside and the gas in the tube was replaced by air. When the oxygen was turned on again the coal began to glow and in four or five seconds there was an explosion accompanied by a distinct click, flame passing from the coal through the tube for a distance of 40 centimeters. The experiment was repeated a number of times. If the oxygen was turned on when the charcoal was incandescent on the outside there was no puff and no flame passed along the tube. A soft porous charcoal gave no puffs.

2.

Experiment 14.—The glass tube shown in fig. 2 contained charcoal at *b* which was kept hot during the experiment. At *a* was a piece of dense wood charcoal a centimeter thick and three long. The two pieces were 40^{cm} apart. Oxygen not dried was supplied through the small tube. When the charcoal at *a* was first heated it took fire without any puff. The oxygen was then turned off and as soon as the coal at *a* ceased to glow air was passed into the tube to displace the gas in it. On turning on the oxygen again the charcoal at *a* commenced to glow and the charcoal at *b* burned brilliantly, showing that the other piece had not consumed all the oxygen. After a few seconds there was a slight explosion. The experiment was repeated many times until the piece at *a* was mostly consumed. The flame accompanying the explosions usually passed from *a* to *b*, but sometimes it passed from *b* to *a*.

In *12* the amount of hydrogen and water present was very small and the explosive mixture of gases may be regarded as consisting of oxygen and carbonic oxide and possibly some carbon dioxide. When the charcoal was glowing feebly carbonic oxide was formed and together with oxygen passed beyond the coal and when the temperature of the burning coal reached the point of ignition of carbonic oxide there was an explosion, and the coal then burned with a flame. In *13* and *14* the gas was used moist and the charcoal also yielded water when burned. But in these experiments the slow oxidation in presence of an excess of oxygen yielded a combustible gas that required a higher temperature than that of feebly burning charcoal to ignite it.

ART. XLII.—*Note on some Volcanic Rocks from Gough's Island, South Atlantic;* by L. V. PIRSSON.

THE rocks which are the subject of this note were gathered as beach pebbles from the shore of Gough's Island, South Atlantic Ocean, lat. 40° 20′ S., lon. 9° 44′ W., by the captain of a whaling vessel from New London, Conn., and they came into possession of the writer through the kindness of Prof. C. E. Beecher of the Peabody Museum in New Haven.

While in general the mere petrographical description of rocks disconnected from their geological occurrence and relationships has little value or interest, the fact that nothing so far as the writer can learn has ever been published on this remote locality, and also that the material developed several points of interest are the reasons for the publication of this note.

Gough's Island was discovered in the sixteenth century by Gonçalo Alvarez, and later by Gough, an English navigator, after whom it is generally called. The island seems to be little known and a search through the literature has given only the information that it is a craggy mass rising to a height of 4350 feet and about eighteen miles around, of a generally agreeable climate, with streams which present several fine cascades and several valleys green with turf and bushes.* Tristam da Cunha, the group of islands lying 240 miles N.W., are of volcanic origin, as others of the detached oceanic islands of the South Atlantic, and from what has been given and the evidence afforded by the present investigation it is probable that the island represents a volcanic cone.

The material consisted of a small number of rounded pebbles, all of which represent very fresh volcanic rocks or tuffs which may be referred either to trachytes or basalts.

Basalt.

This is represented by two varieties, one of which is a rock of a dark gray color thickly dotted with black phenocrysts of augite, yellow olivines and white feldspars of the microtine habit The groundmass is dense and cannot be resolved by the eye alone. The augites are the largest phenocrysts, attaining at times a length of 5^{mm}; the feldspars and olivines are much smaller. In thin section under the microscope the rock is seen to be beautifully fresh and unaltered and the usual minerals to be present, viz: iron ore, apatite, olivine, augite and plagio-

*Cf. Earth and its Inhabitants; Africa, vol. iii, pp. 97. New York, 1888. Appleton & Co.

clase, the last two in two generations. The *augite* is of a pale brownish color, non-pleochroic and shows a marked dispersion of the optic axes emerging from extinction, on one side bluish, on the other yellowish in color. In the second generation it is similar and scattered through the feldspar staves in rounded, irregular granules and often attached to iron-ore grains. The *feldspar* phenocrysts are tabular on *i-ĭ* (010), and from their high extinction angles in the zone $100 \wedge 001$ and on the clinopinacoid (010) it is seen that they are to be referred to labradorite. On the other hand the lath-like feldspars of the groundmass are to be referred to andesite. The usual laws of twinning abound. The other minerals present nothing worthy of mention. In structure the rock is an interwoven mesh of feldspar laths in which the other minerals lie imbedded. It is rather of an andesitic habit owing to the prevalence of the feldspar but from the abundance of olivine and the basicity of the rock, a determination of silica having given 48·61 per cent, it should undoubtedly be referred to basalt. Its specific gravity is 2·890.

The second type of this rock is macroscopically of a dark grayish brown color, weathering to a brown, porous in texture and thickly dotted with white broad lath-like phenocrysts of feldspar which frequently attain a length of from 5–6^{mm} and often group themselves into radial starlike clusters. In thin section iron ores, apatite, olivine, augite and feldspars are disclosed. The *olivine* exists in two forms, in large irregular phenocrysts attaining 1^{mm} in diameter and in small crystals averaging about ·05^{mm}. The larger phenocrysts are undergoing a process of alteration into an orange-red colored mineral. This proceeds inwardly along the edges and cracks and seems to be in two stages which are best observed under crossed nicols. The first stage seems fibrous and gives a rolling extinction, until the second stage is reached where the mineral again becomes apparently homogeneous and extinguishes as such. In this product the orientation of the axes of elasticity are different from the original. In the smaller olivines mentioned the process has been entirely completed and they all appear of this orange-red color but appear otherwise homogeneous and extinguish parallel. A somewhat similar case is mentioned by Michel Lévy* as occurring in the basalts of Mont Dore. It is probably conditioned by a change of ferrous to ferric oxide and is somewhat like the coloration in the olivines in the limburgite of Sasbach.†

* La Chaine des Puys et le Mont Dore, Bull. Geolog. Soc. France, 3d serie, xviii, 1890.

† Rosenbusch, N. J., 1872, pp. 59; also Physiog. d. Min., 1892, pp. 472.

The *augite* as a phenocryst is rare but presents nothing remarkable. The *feldspar* phenocrysts are of labradorite as indicated by their optical properties and by their sp. g. 2·708 taken with a heavy solution and Westphal balance. There is the usual albite and pericline twinning. The *groundmass* consists of fine feldspar laths in character near andesite, the small olivines referred to and between these globulitic material, augite microlites, iron ore, glass, etc. This interstitial material is of a dark grayish brown color in which the colorless feldspar laths lie, looking like slits in the section.

A determination of silica in this rock gave 49·55 per cent and its sp. gr. is 2·643, the lowness of which is no doubt due to the glass of the groundmass. From these and the mineral composition it is evidently to be referred to basalt.

Trachyte.

This is represented by trachytic tuffs and obsidian. The latter is macroscopically, a black, pitchy looking glass filled with pores which by their extension in one direction indicate flow movements in the viscous fluid. Rarely small feldspar phenocrysts are to be seen. Before the blowpipe this glass melts readily, puffing up into a grayish pumice which then melts to glass with the utmost difficulty, a small amount of water present increasing the mobility and lowering the melting point as noted previously by other observers on acid glasses. The chemical analysis of this glass gave the following composition:

Sp. gr. = 2·210		
	SiO_2	61·22
	TiO_2	·42
	Al_2O_3	18·01
	Fe_2O_3	1·32
	FeO	4·51
	MnO	tr.
	MgO	·44
	CaO	1·88
	Na_2O	6·49
	K_2O	5·93
	H_2O	·46
	Total	100·68

From the moderate amount of silica, low lime and magnesia and high alkalies, it is evident that this glass is to be referred to trachyte, perhaps of the phonolithoid type.

In thin section it appears as a fresh unaltered glass of a deep brown color scattered through which are a few grains of iron ore, apatite crystals, an occasional sanidine or olivine pheno-

cryst, and as the final products just before consolidation globulites and small sanidine microlites.

The *olivine* occurs very rarely indeed. It is fresh and of a pale yellow color and shows magnetic resorption. That it is indeed olivine is shown by its optical behavior, its high double and single refraction, its extinction parallel to two cleavages at about right angles, one of which is more pronounced than the other, and its general outline and habit.

This was confirmed by treatment of the powdered rock by hydrofluoric acid according to Fouqué's method of isolation and in the residue the lens disclosed a number of the olivines which were carefully picked out and subjected to qualitative analysis. This proved the mineral to be a silicate soluble in hydrochloric acid and in the solution were only iron and magnesia, lime not being present. The mineral is therefore undoubtedly an olivine and one rich in iron. The method of isolation also showed that it was very scarce in the rock. The crystals attain a size of ·5 to 1^{mm}.

The presence of olivine in trachytic rocks is not unknown. It is mentioned by Mügge* as occurring in the trachytic lavas of the Azores, by Michel Lévy† in augite trachyte of Monte Dore which is however of an andesitic type, and by Fuchs‡ as an accessory component of the trachyte of the Arso stream on the island of Ischia. Its occurrence in the present case in a magma containing less than ·5 per cent of magnesia is, however, remarkable and to be paralleled with its presence in the rhyolite of Iceland as shown by Bäckström,§ and that of fayalite in the rhyolitic obsidian of the Yellowstone Park,‖ and of the Lipari Islands¶ as shown by Iddings. The latter author parallels such occurrences with that of sporadic quartz grains in basalt** and refers their origin to the mineralizing tendency of included water vapor in highly heated magmas under conditions of great pressure. In the present case the corroded state of the olivines evinces that in the later chemical and physical conditions under which the magma consolidated, the compound as a chemical one was incapable of existing and that it was therefore formed under different ones. The fact that the magma chilled as a glass proves that it was ejected and cooled with comparative rapidity, and it is reasonable to infer that such ejection through comparatively long and narrow conduits must be accompanied by varying degrees of pressure and with

* N. J., 1883, ii, pp. 217.

† Bull. Geol. Soc. France, 3d series, xviii, pp. 812.

‡ Tschermak Mitth., 1872, pp. 224.

§ Geol. Fören. Förhandh., xiii, No. 7, pp. 644.

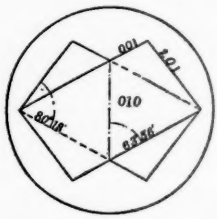
‖ This Journal, vol. xxx, p. 58, 1885; cf. also 7th Ann. Rep. U. S. G. Surv., pp. 270, 1888.

¶ This Journal, vol. xl, p. 75, 1890.

** This Journal, vol. xxxvi, p. 208, 1888.

comparatively slight variations of temperature. Such increase of pressure may be sufficient to condition the crystallization of compounds which later under lower pressures would be incapable of existing, the mobility of the magma being increased by the presence of water vapors as shown by the author cited and thereby conditions more favorable for the production of the compound.

Feldspar is scattered freely through the glass in small microlites of sanidine in flat tables of excessive thinness and twinned according to the Carlsbad law. They are outlined by the base (001), clinopinacoid (010) and positive hemidome ($\bar{2}01$) and appear as in the annexed figure. They are sometimes solitary and sometimes grouped into somewhat spherical aggregates and thus exhibit the only tendency toward spherulitic structure observed in the rock.



Globulites are present composed largely of minute specks of iron ore as is shown by the colorless zones surrounding them, from which they have extracted the ferruginous coloring matter of the glass.

Tuffs are represented by several specimens. They are soft, light brown in color and enclose fragments of volcanic rock. In thin section they are seen to be composed of fragments of glass which are generally very fresh, mingled with broken crystals of sanidine and augite.

In conclusion it is of interest to note that in thus establishing, as is evinced by the material investigated, the recent volcanic nature of this solitary island, there is one more added to that line of mid-Atlantic volcanoes, which sweeping southward through the Azores, Cape Verde Islands, Ascension, St. Helena, Tristam da Cunha, and Gough's Island, terminates its volcanic fires on Bouvet Island on the confines of the Antarctic Ocean.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, New Haven, Jan., 1893.

ART. XLIII.—*On a Champlain (?) deposit of Diatomaceæ belonging to the Littoral Plain;* by ARTHUR M. EDWARDS, M.D.

ON the 30th of March, 1859, F. C. S. Roper read a paper by me before the meeting of the Microscopical Society of London, and which was published in volume vii of the Transactions, "On Diatomaceæ collected in the United States." In it there is spoken of a gathering made at Hoboken, N. J., in which eighty-six species of Diatomaceæ, from fresh, brackish and salt water are mentioned as coming from that locality. This gathering, or rather these gatherings, for there were more than one hundred made at that time, were mostly from a large brook, the mud of which yielded the shells of the dead Diatomaceæ. At that time I did not try to work out the geology of the deposit, only pointing out that the mixture of marine, brackish and fresh water forms in the deposit was curious. Since that time I have kept the matter in view and am now prepared to assert what I believe to be the geology of the deposit. I shall show that the Diatomaceæ in it, and by which its geology is determined, are widely spread.

It is the first time that Diatomaceæ are found at all in the geological scale and referred to the brackish, although they are indicated by Ehrenberg in the Mikrogeologie, 1854, as coming from Norwich, Conn. This I will show is the same as those.

They are known to be marine and are referred to the Eocene, Oligocene or Miocene Tertiary. These are from Paita, Peru; San Pedro (or farther south in Southern California) to Sub Little Mines, Del Norte Co., in California; Petersburg, Virginia, to Atlantic City, New Jersey; Oran, in Africa; Mors, in Denmark; Simbirsk, in Russia; Sentz Peter, in Hungary; Moron, in Spain; Nicobar Island, in the Bay of Bengal; Cuba, Trinidad and Barbadoes, in the West India Islands; Sandai, Kobe and Netanai, in Japan; the Island of Sicily and Omaru, in New Zealand.

On the 18th of December, 1871, I read a paper before the Lyceum of Natural History, New York, "On a deposit of marsh-mud upheaval by superincumbent pressure and containing the remains of shells of Mollusca and microscopic organisms," which was not then published, but is now for the first time in the microscopic notes for January 1, 1893. As this records the instance of the shells of marine and brackish Diatomaceæ in this deposit also, it now sees the light. The third instance of marine, brackish and fresh-water Diatomaceæ mixed I have now to publish. This deposit I have studied for over three years past. Besides the many spots on the

Newark meadows, N. J., where I have collected the Champlain (?) deposits, I will mention the following as typical, and from which I have gathered the clay, blue, gray or white, and made slides: Harrison, near the bridge; opposite Athar's factory; opposite Lister's factory; by Hillingsworth's factory; between Hillingsworth's factory and the P. R. R. bridge; Frank Creek, half way across the meadows; near the P. R. R. No. 1 and No. 2; near the bridge over the Passaic River; on the extension of the P. R. R.; raised meadows on the P. R. R.; Woodruff's Creek, near Elizabeth; near Linden Park No. 1 and No. 2, Elizabeth; back of Jersey City; in Jersey City, at the third street from New York Bay; Elizabethport; Bay Way, Elizabethport; Kingsland; Sewarren; Kearney; Peddie Street Ditch; Signal post on the L. V. R. R., Bound Creek; and Arrowchar, S. I., N. Y. Besides these I have the same clay from near New Haven, collected by myself, and also sent to me by Mr. W. A. Terry, of Bristol, Conn.; near Boston, Mass., from Mr. F. F. Forbes and Mrs. S. A. Fuller; also from Mr. L. Woolman, as clay, water works, Absecon, N. J.; Bingham House, No. 1 and 2, Philadelphia, Penn.; 11th and Market streets, Philadelphia; Spreckel's Refinery, Reed Street Wharf, Philadelphia; abutment Walnut Street Bridge, Philadelphia; Gray's Ferry, B. & O. R. R, and he records in the Microscopical Bulletin for October, 1892, "Fossil Diatoms in Philadelphia beneath the girls' new Normal School buildings." And I am also indebted to Mr. C. L. Peticolas for a slide from Cornfield Point, St. Mary Co., Md. I have also to record that Professor J. W. Bailey discovered in the earth of the rice fields at Savannah, Ga., Diatomaceæ. This I received at the same time, about forty years ago, from Dr. W. C. Daniels, Savannah, Ga. Bailey records it in his Microscopical Observations made in South Carolina, Georgia and Florida, and published in 1850 in the Smithsonian Contributions to Knowledge, Vol. II, page 5. Dr. F. W. Lewis records the finding of Diatomaceæ in the blue clay of the Delaware River, Philadelphia, Penn., in his Notes on new and rarer species of Diatomaceæ of the United States seaboard, 1861.

We now come to mention the species of Diatomaceæ found in the Champlain (?) deposits of the Littoral Plain. They include the following:

Achnanthes hirta, O. F. M., lanceolata, A. de B.
Actinocyclus ternarius, C. G. E.
Actinoptychus biternarius, C. G. E.
Amphiprora alata, C. G. E., lepidoptera, W. G., pulchra, J. W. B.
Amphora cymbifera, W. S., lanceolata, P. T. C., pellucida, W. G., robusta, W. G., undata, H. L. S.
Amphitetras antediluviana, C. G. E.
Brebissonia lanceolata, C. A. A.

Biddulphia aurita, A. de B., lævis, C. G. E., pulchella, S., radiata, F. C. S. R., rhombus, C. G. E., turgida, C. G. E.

Campylodiscus clypeus, C. G. E., echeneis, C. G. E.

Cocconeis diaphana, W. S., distans, W. G., limbata, W. G., major, W. G., oceanica, C. G. E., placentula, C. G. E., scutellum, C. G. E., undulata, C. G. E.

Cocconema cistula, H., lanceolatum, C. G. E.

Coletonema eximium, F. T. K., vulgare, T.

Coscinodiscus asteromphalus, C. G. E., excentricus, C. G. E., lacustris, A. G., nitidus, W. G., radiatus, C. G. E., sol, G. C. W., subtilis, C. G. E.

Cyclotella carconensis, S. G., operculata, F. T. K., kützingiana, T.

Cymbella stomatophora, H. G., truncata, W. G.

Cymatopleura elliptica, A. de B., quinquepunctata, F. T. K.

Diploneis apis, C. G. E., elliptica, F. T. K.

Denticula minor, A. G.

Doriphora amphiceros, F. T. K.

Encyonema paradoxum, F. T. K., prostratum, J. R.

Epithemia Jurgensii, C. A. A., gibba, F. T. K., gibbula, F. T. K.

Eunotia arcus, C. G. E., gracilis, C. G. E., incisa, W. G., lunaris, A. de B., pectinalis, S. R.

Fragilaria Pacifica, A. G., virescens, S. R.

Gomphonema acuminatum, C. G. E., cupitatum, C. G. E., constrictum, C. G. E., ? curvatum, F. T. K., cristatum, S. R., mamilla, C. G. E., marinum, W. S.

Hyalodiscus scoticus, F. T. K., stelliger, S. W. B.

Lyradiscus ovalis, R. K. G.

Mastoglota lanceolata, W. S., Smithii, T.

Meridion circulare, C. A. A.

Melosira crenulata, F. T. K., grandis, M. P., granulata, C. G. E., Jurgensii, C. A. A., nummunloides, C. A. A., punctata, A. G., sulcata, C. G. E., undulata, F. T. K., varians, C. A. A.

Navicula Americana, C. G. E., bacillum, C. G. E., borealis, C. G. E., cancellata, A. S. D., Couperi, T. W. S., cruciformis var. brevior, P. T. C., cuspidata, F. T. K., dactylus, C. G. E., Dariana, A. G., elegans, F. T. K., esox, C. G. E., firma, F. T. K., gigas, C. G. E., gibberula, F. T. K., gracilis, C. G. E., granulata, A. de B., Henedyii, W. S., interrupta, F. T. K., Lewisiana, R K. G., lyra, C. G. E., major, F. T. K., maxima, W. G., minutula, W. S., Mexicana, C. G. E., nobilis, C. G. E., oblonga, F. T. K., peregrina, C. G. E., radiosa, F. T. K., spherophora, C. G. E., stauroneiformis, W. S., (tenuis Grey var. ?) sublineais, W. G., trinodis, W. S., viridis, F. T. K., viridula, C. G. E.

Nitzschia, acicularis, F. T. K., amphioxys, C. G. E., Brightwellii, F. K., bilobata, W. S., constricta, F. T. K., compressa, J. W. B., fasciculata, A. G., obtusa, W. G., Peruviana, C. G. E., paradoxa, G., reversa, W. S., scalaris, C. G. E., sigma, F. T. K., sigma, var. major, A. G., sigmoidea, C. G. E., subrecta var. rigida, A. G., tryblionella, H., (tryblionella var. ?) littoratis, A. G.

Plagiogramma Gregorianum, R. K. G.

Pleurosigma angularis, W. S., Balticum, C. G. E., delicatulum, W. S., oximium, F., elongatum, W. S., fasciola, F. T. K., hippocampus, C. G., obscurum, W. S.

Podosira monilformis, C. G. E., Montagnei, F. T. K.

Pyxilla ? Baltica, A. G.

Rhabdonema Adriaticum, L., arcuatuaum, F. T. K.

Synedra affinis, F. T. K., lunaris, C. G. E., pulchella, F. T. K., salina, W. S., tabulata, F. T. K., ulna, F. T. K.

Stictodiscus craticula.

Stephanodiscus corona, C. G. E., Niagaræ, C. G. E.

Stauroneis acuta, W. S., anceps, C. G. E., aspera, W. S., salina, W. S., legumen, C. G. E., maculata, J. W. B., phœnicenteron, C. G. E., pteroidea, C. G. E., gracilis, C. G. E., fenestra, C. G. E.

Surirella acuta, C. G. E., Brightwellii, W. S., crumena, A. de B., cardinalis, F. K., Davidsonii, A. S., Fastuosa, C. G. E., gemma, C. G. S., gracilis, A. G., linearis, W. S., Molleriana, A. S., ovalis, A. de B., Ratrayii, A. S., recedens, A. S., robusta, C. G. E., splendida, C. G. E., salina, W. S., Suevica, Z.

Schizonema cruciger, W. S., divergens, W. S., hyalina, W. S., Smithii, C. A. A.

Tetragramma Americana, T. W. B.

Tabellaria fenestrata, F. T. K., flocculosa, F. T. K.

Triceratium alternans, T. W. B., favus, C. G. E., reticulum, C. G. E.

Van Heurkia rhomboides, A. de B.

We now come to the geology of the Newark Champlain (?) deposit. I understand the Champlain deposit to be formed when the melting of the glacier which succeeded the Tertiary age. The first were glaciers forming the glacial period and then they melted and formed the Champlain period. When the glaciers were nearly melted, the Diatomaceæ lived in the fresh water, and their shells were deposited when the stream of the Champlain period rushed down from the North. The deposit was mostly clay and covered the states where it is now found. From New Brunswick to Pennsylvania on the Atlantic coast of North America it is formed covering the whole country. The clay was of course fresh water, and the Diatomaceæ were also fresh water. By and by salt water flowed in and formed brackish pools on the coast. As this was raised a brackish clay was formed, and this I call the raised or sunken beach. Dr. J. S. Newberry calls it the Littoral Plain. He describes it in the geological history of New York Island and harbor in the Popular Science Monthly, vol. xiii. The fresh-water deposits are innumerable, but really are one and form the clay at the bottom. Upon this is the raised coast. The raised coast forms two deposits in the Newark meadows. Upon this is a clay of fresh water Diatomaceæ, and lastly comes the recent clay now forming.

Art. XLIV.—*Refraction of Light upon the Snow;** by Albert W. Whitney.

Under certain conditions involving the character of the snow and the altitude and brilliancy of the sun, the glitter of the snow is not uniform. Make these conditions, then, a cold, clear, winter afternoon, about half an hour before sunset, and a rather fresh field of snow, and the following description becomes general.

Two roughly V-shaped paths, of especial, not exclusive, brilliancy, open away from the observer and towards the sun; the apex of one is perhaps six feet away, its angle 90°; the apex of the other is perhaps 15 feet away, its angle 60°.

The following facts are to be noted:

First, the light is not diffused; it is made up of many separate brilliant points.

Second, the paths are broad, several degrees in width.

Third, the inner margin is rather sharply defined; there is no such clear outer limit.

Fourth, the path nearer to the sun is brighter—the separate points of light are visible twice as far away as those in the nearer path.

Fifth, while the general glimmer of the snow is apparently colorless, the points which lie in the paths glow most brilliantly with prismatic colors; blues pure and clear as the bluest sky, greens as delicate as the emerald, reds as glowing as the fiery opal. With a movement of the head which brings a blue crystal towards the inner edge of the path, its color passes through all the tints of the spectrum; a movement in the other direction reverses the succession of colors. Within the limits of the path, the colors at first seem to be scattered promiscuously; more careful observation, however, leads one to feel that there is a slight tendency in the reds to keep to the inside.

A large number of measurements with the sextant have made it evident that the angle between the eye, the glowing point, and the sun, is not only constant as regards all other points of like position on the path but also for varying altitudes of the sun. The supplement of this angle, measured from the part of the greatest brilliancy, is for the nearer path about 46°, for the further path about 22°. Let us call this in general δ.

Without seeking a cause for the condition, it is easy to determine what, under this condition, the path must be. The locus of points at which a constant angle is made between

* Abstract of a paper read before the Beloit College Scientific Association, Feb. 14, 1893.

parallel lines and lines to a given point is the surface of a cone. In this case, the eye is the apex, the axis the line of sunlight, the angle at the apex is 2δ. It will be seen at once that the snow-surface is a plane which cuts this cone. The conic section produced depends upon the relation of the altitude of the sun and δ. In both cases, where $\delta = 22°$ and $46°$, the figure on the snow is evidently a hyperbola. When the altitude of the sun $= \delta$, the figure is at infinity; the sun has an altitude of more than 22° till about the middle of the afternoon; hence before this time the inner hyperbola is invisible. As even at noon the sun is not higher than 37°, the outer hyperbola is visible at all times. The effect of the going down of the sun is evidently to broaden the figures and bring them nearer.

We have now proved inductively that δ is constant, and deductively that, δ being constant, the figure is an hyperbola. It remains to find a cause for the constancy of δ.

The light from the snow is evidently due either to reflection or refraction; most of it is doubtless reflected. Several facts already mentioned seem to prove, however, that the light of the hyperbolas is not due to reflection.

First, the only intrinsic law of reflection, that of the equality of the angles of incidence and reflection, is seen to be no path-discriminating condition—for the facets of the snow-crystals may be tilted at any angle.

Second, reflection cannot account for the color. Therefore this phenomenon must be due to refraction. The difference is apparent between the light from the crystals lying in and out of the path. As one turns his head, those crystals lying outside flash for an instant, and as quickly subside; those in the path, on the other hand, linger to run through their little life of color. At noon the altitude of the sun is about 37°; the complement of the polarizing angle of ice is 37° 20′. Hence at this time the reflected light near the vertex of the hyperbola should be nearly all polarized. Experiments with Nicol's prism and tourmaline prove that nearly all the general glimmer is cut off, while the light of the hyperbola is undisturbed.

The problem is now simplified to that of finding a phenomenon of refraction to correspond with the constancy of δ. The angle of minimum deviation seems to promise a solution; it will evidently give a maximum, for at this point the refracted light is greatest. It will also give a sharp inside limit to the path and an indefinite outside limit, which exactly corresponds with observation.

Now ice belongs to the hexagonal system; it may form in right hexagonal prisms. Consequently a snow-crystal may offer to the light angles of 60°, 90°, and 120°. There will evidently be no emergence in the case of the 120° angle.

The formula, $\delta = 2 \sin^{-1}\left(n \sin \frac{A}{2}\right) - A$, gives for the angles of minimum deviation, where n, the refractive index of ice, is 1·31, and A is first 60° and then 90°, the angles 21° 50′ and 45° 44′, which correspond very closely with observation.

The greater brilliancy of the 22° hyperbola corroborates the theory also, for evidently less light is transmitted through a 90° prism, than through one of 60°, owing to the greater obliquity of the incident rays in the former case.

To sum up, in a field of snow crystals tilted at all possible angles, not one can send a refracted ray to the eye unless, first, it lies in the path of the hyperbola, and, second, it is tilted at just the right angle.

The resemblance of this theory to that of halos, or, in fact, the real unity of the two, is manifest. The halo and the snow-hyperbola are respectively the aerial and terrestrial portions of the same phenomenon; the comparison in detail is very interesting.

Some rays of light doubtless experience internal reflection. Hence other conic sections are within the range of possibility. The simplest such case, that of one internal reflection, where the maximum is given by the critical angle, would give angles corresponding to δ of about 87° and 116°. Some color may be seen throughout this region, but I have not been able to detect anything definite enough to be called a path.

The perspective of these snow-hyperbolas forms concentric circles upon a plane normal to the path of the sun's rays, which is also evident from the fact that they are the completion of the halos. On a vertical plane the perspective forms ellipses.

Another interesting fact concerns the relation of the other limb of the hyperbola to that upon the snow. If the observer walks so as always to keep one certain point in the path of light, his track will be an hyperbola; if now, from the apex of the hyperbola which he has traced, he advances a distance equal to his height multiplied by the cotangent of the angle, the altitude of the sun plus δ, the figure which he now sees and the figure which he has traced upon the snow are the two limbs of the same hyperbola.

The difference between the refractive indices for red and violet light gives theoretically a dispersion of 46′ in the case of the hyperbola of 22°, and of 2° 10′ in the case of the hyperbola of 46°. It may be noticed that the colors in the nearer figure are more conspicuous. I do not understand, however, why the arrangement of color is not more regular. It may be due to an inability of the eye to sum up this discrete color. The hyperbola is produced by a single layer of crystals, the

halo by a mass of crystals perhaps hundreds of feet in depth; hence in the latter case the summation is already made.

Refraction upon the snow is largely, perhaps mostly, due to frost-crystals. They form more slowly, hence more regularly, than snow-crystals; they are inconspicuous upon a snow-surface. Snow-hyperbolas are usually more obvious in late afternoon than in the early morning. I have thought that possibly the following may be in the line of an explanation of this: the frost-crystals need a certain amount of clearing up by sun and wind of minute secondary accumulations of frost upon themselves, to make them fit for transmitting light.

ART. XLV.— *Value of the force exerted by a current of Electricity in a circular conductor on a unit magnetic pole at its center;* by S. T. MORELAND.

THE following method of finding this value is new so far as I know.

Let i = strength of current
r = mean radius of the conductor supposed to make one turn.

So far as magnetic effects are concerned it is known that such a current produces the same result as a *magnetic shell* having its boundary in the circle and satisfying the condition

$$i = It$$

where I is the uniform surface density of the magnetism and t is the thickness of the shell. Substitute a *hemispherical magnetic shell* for the current in this case having plus magnetism on the inner surface and minus on the outer, the total quantity on each of the two surfaces being equal.

Let σ_i = surface density on inner surface.
σ_a = " " " outer "
r_i = radius of inner surface.
r_a = " " outer "

Then $r_a - r_i = t$, a very small quantity, and $r = \sqrt{r_i r_a} = \frac{r_i + r_a}{2}$ very nearly, and $I = \sqrt{\sigma_i \sigma_a} = \frac{\sigma_i + \sigma_a}{2}$ very nearly.

Also $$\sigma_i : I = \frac{1}{r_i^2} : \frac{1}{r^2}$$

$$\therefore \sigma_i = I\frac{r^2}{r_i^2}.$$

Similarly $$\sigma_{ii} = I\frac{r^2}{r_{ii}^2}.$$

The resultant repulsion of the magnetism of the inner surface on the unit pole at the center is $\pi\sigma_i$ and the attraction of the outer surface is $\pi\sigma_{ii}$. Hence,

Resultant force of magnetic shell $= \pi(\sigma_i - \sigma_{ii})$

$$= \pi I r^2 \left(\frac{1}{r_i^2} - \frac{1}{r_{ii}^2}\right) = \pi r^2 \frac{(r_{ii}^2 - r_i^2)}{r_i^2 r_{ii}^2}$$

$$= \pi I \frac{r^2}{r^4}(r_{ii} + r_i)(r_{ii} - r_i)$$

$$= \frac{\pi I}{r^2} 2rt = \frac{2\pi i}{r}$$

which is the result sought.

We see too that in the equation

$$I = it$$

I is the mean of the two surface densities which must necessarily differ in value unless the shell is a plane.

ART. XLVI.—*On Cookeite from Paris and Hebron, Maine;* by SAMUEL L. PENFIELD.

THIS mineral was first described as a new species in 1866 by Professor George J. Brush,* and only a limited supply of pure material could be obtained at that time for the chemical analysis, which was made by Mr. Peter Collier. In the summer of 1891 Professor Brush visited the localities of Paris and Hebron and obtained there some excellent specimens of Cookeite, from which abundant material suitable for analysis could be obtained, and at his suggestion the mineral has been reëxamined.

Cookeite is related to the chlorites and micas, having a distinct basal cleavage and crystallizing like them in the monoclinic system. The largest crystals that the author has observed are not over 3^{mm} in diameter and are hexagonal in habit. Dis-

* This Journal, II, xli, p. 246.

tinct six-sided prisms are rarely found; the crystals are usually radial as if made from a series of wedge-shaped hexagonal plates, fig. 1, grouped with their thin edges together, fig. 2. The form is something like that of prochlorite, figured on page 653 of the sixth edition of Dana's Mineralogy, only more bent. The exterior of the crystals is rather rough, so that they look almost hemispherical or globular. The cleavage plates are naturally wedge-shaped like fig. 1, which interferes somewhat with making exact optical determinations. When examined in polarized light they appear divided up very symmetrically into sectors fig. 3. The inner portion *a* is uniaxial and shows a weak, positive double refraction. The outer por-

1. 2. 3.

tion or rim is composed of six segments, the opposite ones extinguishing simultaneously in directions indicated in the figure, showing that this outer portion may be regarded as a trilling, composed of penetrating individuals. In each segment the acute bisectrix is about at right angles to the section and the plane of the optical axes is parallel to the edge of the hexagon, corresponding to the clinopinacoid. The bisectrix is also slightly inclined in the same plane. The divergence of the axes is large, considerably greater than that of muscovite, although it could not be measured exactly owing to the small size of the sections. The double refraction is positive and not very strong, being about like that of the chlorites. The uniaxial central portion *a*, fig. 3, may be considered as composed of biaxial plates, superimposed on one another in twin position according to Tschermak's law of twinning for the chlorites.* The relative proportion of center and rim varies. In some sections the center is almost wanting, the rim, however, is always prominent and shows with the microscope a faint striated structure, the striæ running at right angles to the edge of the hexagon, as represented in the figure. Except for the uniaxial center the above method of twinning is exactly like that of the clinochlore from Texas, Lancaster Co, Pa., described by Professor J. P. Cooke,† after whom this mineral was named.

* Sitzungsber. d. kais. Akad. d. Wissenschaften in Wien (1), xcix, p. 174, 1890.
† This Journal, II, xliv, p. 201.

Cookeite is associated with quartz, lepidolite and tourmaline (especially the variety rubellite) and apparently has resulted from the alteration of the latter, as suggested by Professor Brush. One of the best and most interesting specimens of the mineral in the Brush collection is a deposit of the mineral on a large tourmaline crystal. This latter has a triangular prismatic habit, terminated by a basal plane and is over 4^{cm} in diameter. As a subsequent process the tourmaline has been mostly removed, leaving a cellular interior, containing cookeite, a few quartz crystals and remnants of the original tourmaline, etched out into slender prisms and spicules reminding one of the etched beryls (aquamarines) from Mt. Antero, Colorado.* The cookeite here is plainly a secondary mineral and in this respect, as well as in its crystalline habit, mode of twinning and optical properties it is related to the chlorites. It is also like some varieties of vermiculite in its pyrognostic properties. When heated before the blowpipe it exfoliates prodigiously, giving at the same time a lithia color to the flame.

The material for analysis was carefully selected from a specimen from Paris where the cookeite was associated with quartz and tourmaline, thereby avoiding any contamination with lepidolite. The results of the analysis are given below together with the original analysis of Mr. Collier.

	Author.			Ratio.			Collier.
Specific gravity	2·675						2·70
	I.	II.	Mean.				Mean.
SiO_2	34·00		34·00	·567		4·00	34·93
Al_2O_3	45·13	44·98	45·06	·442		3·11	44·91
Fe_2O_3	0·45		0·45				
CaO	0·04		0·04				
K_2O	0·11	0·16	0·14	·001	·138	0·97	2·57
Na_2O	0·20	0·17	0·19	·003			
Li_2O	4·14	3·89	4·02	·134			2·82
H_2O	14·85	15·06	14·96	·831	·843	5·94	13·79
F	0·46		0·46÷38	·012			SiF_4 0·47
O equivalent to the F			99·32 19				99·49
			99·13				

The ratio in the author's analysis corresponds closely to $SiO_2 : Al_2O_3 : Li_2O : H_2O = 4 : 3 : 1 : 6$ giving the formula $H_{12}Li_2Al_6Si_4O_{24}$, or simplified to that of a basic metasilicate,

* This Journal, III, xl, p. 488, 1890.

$Li[Al(OH)_2]_3Si_2O_6$. Below will be found the author's analysis simplified by regarding all of the alkalies as represented by their equivalent of Li_2O, the Fe_2O_3 as Al_2O_3 and the F as OH and the whole calculated to one hundred per cent, also the percentage composition from the proposed formula.

	Analysis as adjusted.	Theory.
SiO_2	34·46	35·09
Al_2O_3	45·95	44·74
Li_2O	4·21	4·38
H_2O	15·38	15·79
	100·00	100·00

The agreement is certainly satisfactory and the discrepancy is probably the result of some slight impurity, which it is hard to avoid in micaceous minerals. Most of the water is expelled from cookeite at a high temperature, showing that it is probably formed from hydroxyl as assumed in the formula given above. The analysis was made on air-dry powder and the following fractional determinations were made:

Twenty hours over sulphuric acid in a desiccator,	0·82	per cent	loss.
One hour at 100° C.	0·09	"	"
One hour at 300° C. (to constant weight)	0·91	"	"
Total	1·82	"	"

If this small amount of water is deducted from the analysis the ratio of $SiO_2 : H_2O$ is nearer 4 : 5 but the formula then becomes much more complicated.

The essential difference between the author's analysis and that of Mr. Collier is in the alkalies, and it is impossible to give any explanation of his potash determination except that the material for the same was possibly contaminated with lepidolite.

Mineralogical Laboratory of the Sheffield Scientific School,
New Haven, January, 1893.

Art. XLVII.—*Mineralogical Notes;* by Samuel L. Penfield.

The author takes this opportunity of expressing to the Director of the U. S. Geological Survey his obligations for the privilege of presenting the results of the following mineralogical studies, which have been made upon material collected by the writer during the summer of 1892, while engaged in survey work.

1. *Zunyite from Red Mountain, Ouray Co., Colorado.*

In 1884 Mr. W. F. Hillebrand* described a new mineral zunyite from the Zuñi Mine, near Silverton, San Juan Co., Colorado. It is interesting to know that a second locality has been found for this rare mineral, at the Charter Oak mine, situated on the hill, only a short distance east of the village of Red Mountain. This is about five miles north of the original locality and on the same mountain chain.

When visiting the mine, my attention was called by the superintendent, Mr. C. A. Taylor, to a very hard rock which had been taken from the shaft. This is fine grained, of a grayish white color, and with the lens one can readily detect the little bright tetrahedrons of zunyite, about 1^{mm} in diameter, sometimes scattered sparsely, sometimes abundantly, through it. An examination of thin sections with the microscope shows that the rock is a porphyrite, very much altered by steam and fumerole action, so that only remnants of the original minerals are left. The zunyite crystals are fresh and clear and show no double refraction with polarized light.

The pulverized rock was almost an ideal one to treat with the Thoulet solution. An approximate separation of the zunyite crystals was first made. This product was then further purified by digesting with dilute hydrochloric and hydrofluoric acids, which have no appreciable solvent action on the zunyite, and then again separated with the heavy solution, giving a very pure product. Most of the mineral had a specific gravity between 2·904 and 2·876 and only this portion was used for the chemical analysis, the results of which are given below, together with the original analysis of Mr. Hillebrand.

	I.	II.	Average.	Ratio.		Hillebrand
SiO_2	24·11	24·10	24·11	·402	3·00	24·33
Al_2O_3		57·20	57·20	·561	4·18	57·88
Fe_2O_3		·61	·61			·20
Cl	2·61	2·62	2·62	·074		2·91
F	5·92	5·70	5·81	·306	1·616 12 06	5·61
H_2O	11·06	11·18	11·12÷9=1·236			10·89
P_2O_5		·64	·64			·60
CaO		·11	·11			K_2O ·10
Na_2O		·48	·48			·24
			102·70			102·76
O equivalent to Cl and F			3·03			3·02
			99·67			99·74

The analysis was made on air-dry material which lost only 0·06 per cent by drying for one hour at 100° C. and an additional 0·15 per cent by heating for one hour at 300° C. The water is therefore regarded as formed from hydroxyl, with

* Proc. Col. Soc., i, p. 124, 1884. Also Bulletin No. 20, U. S. Geological Survey, p. 100.

which the Cl and F are isomorphous. Disregarding the small amounts of P_2O_5, $CaO.Na_2O$ and Fe_2O_3 the ratio of SiO_2 : Al_2O_3 : (Cl . F.OH) is nearly 3 : 4 : 12, which is required by the formula suggested by Professor P. Groth* $[Al(Cl.F.OH)_2]_6 Al_2Si_3O_{12}$. The agreement between the author's and Mr. Hillebrand's analyses is very satisfactory. Especially the percentages of Cl, F and hydroxyl, which are regarded as isomorphous, are very close and yet there seems to be no definite proportion in which these constituents are related to one another. The relation of Cl+F : OH in the author's analysis is ·380 : 1·236 or 1 : 3·25.

Besides the occurrence of zunyite in the rock, as just described, it also occurs at this same mine in a pulverulent form. This material resembles some kinds of kaolin, is pure white and consists of minute crystals, so loosely aggregated that they can be disintegrated by rubbing between the fingers. Other minerals found at the mine are enargite, pyrite, scorodite and sulphur. The latter in small but highly modified crystals showing the faces, 100, i-$\bar{i}$; 010, i-$\bar{i}$; 110, I; 101, 1-$\bar{1}$; 103, $\frac{1}{3}$-$\bar{3}$; 011, 1-$\bar{1}$; 111, 1; 113, $\frac{1}{3}$; 115, $\frac{1}{5}$ and 133, 1-$\breve{3}$. The scorodite was determined by proving it to be a hydrous ferric arseniate of specific gravity 3·209. It is not crystallized but has formed as a green, botryoidal incrustation on the enargite and decomposed rock.

The author also visited the Zuñi mine near Silverton where the zunyite occurs intimately mixed with the sulpharsenite of lead, guitermanite, and an earthy decomposition product containing lead sulphate, as described by Mr. Hillebrand. Some crystals were also found in the wall rock, which, like that from Red Mountain, is a decomposed porphyrite. At both localities zunyite is plainly a secondary mineral and has probably been formed by fumerole action upon the silicates of the rock.

The author takes pleasure in expressing to Mr. C. A. Taylor of Red Mountain, and to Mr. R. H. Williams of Silverton, the discoverer and owner of the Zuñi mine, his obligations for their kindness in supplying him with specimens and information.

2. *Xenotime from Cheyenne Mountain, El Paso Co., Colorado.*

The occurrence of this mineral from the tysonite and bastnaesite locality of El Paso County has already been noted by Mr. W. E. Hidden.† His description was confined to a single crystal, measuring over one centimeter in diameter, weighing 5·1 grams and which had suffered some superficial alteration. The crystal to be described in the present article was given to

* Tabellarische Uebersicht der Mineralien, 1889, p. 104.

† This Journal, xxix, p. 249, 1885.

the writer by Mr. J. G. Hiestand of Manitou, Colo. It is over one centimeter in diameter and is implanted on a gangue of quartz and feldspar. Associated with it are crystals of hematite and astrophyllite. The xenotime is very fresh and pure, has a brown color and in thin splinters is pale pink. The form of the crystal is the unit pyramid with its middle edges slightly modified by the prism and a steeper pyramid, probably 331, but the faces of the latter were too dull to measure on the reflecting goniometer. The faces of the unit pyramid were bright and the following measurement was made, $111 \wedge 1\bar{1}1 = 55° 32'$, agreeing very well with the measurements of G. vom Rath* and C. Klein,† 55° 30′. The prismatic cleavage was very well shown by cracks running through the crystal.

Without destroying the specimen a little over 0·2 gram was removed for a quantitative analysis, the results of which are as follows:

Specific gravity	5·106		Ratio.	
P_2O_5	32·11	÷ 142 =	·226	1·00
$(Yt, Er)_2O_3$	67·78	÷ 284 =	·238	1·05
Ignition	·18			
	100·07			

The only metals that were found were those of the yttrium and erbium group and the joint molecular weight of the oxides was found to be 284, equivalent to a joint atomic weight of 118. A solution of the oxides tested with the spectroscope showed the absorption bands of erbium and the atomic weight indicates that yttrium is also present. The ratio of $P_2O_5 : (Yt, Er)_2O_3$ is almost 1 : 1 showing that the mineral is a normal phosphate.

The author desires to express his thanks to Mr. J. G. Hiestand for giving him this interesting crystal which is now in the United States National Museum.

ART. XLVIII.—*The Influence of Free Nitric Acid and Aqua Regia on the Precipitation of Barium as Sulphate;* by PHILIP E. BROWNING.

[Contributions from the Kent Chemical Laboratory of Yale College—XXII.]

THE fact demonstrated by Dr. F. W. Mar‡ in an interesting series of experiments, that free hydrochloric acid even in large quantities does not interfere with the complete precipitation of barium as sulphate when sulphuric acid is present in

* Pogg. Ann., 1864, B. 123, p. 187. † Jarb. Minn., 1879, p. 536.
‡ This Journal, xl, 283.

sufficient excess, but rather renders the precipitate more crystalline, and therefore more easily and quickly filtered, suggested a similar series of experiments having as their object an investigation of the influence of free nitric acid on the same precipitation. Certain qualitative preliminary experiments showed a similar effect to that brought about by hydrochloric acid as regards the crystalline form and rapid settling of the precipitate. It therefore remained to determine whether the nitric acid present had any solvent effect upon the precipitate. Accordingly a standard solution of barium nitrate was prepared, free from alkali, by precipitating a soluble barium salt with ammonium carbonate, washing thoroughly with hot water and dissolving in nitric acid, care being taken to avoid an excess of the acid, and making up to measure. Definite portions of this solution were drawn from a burette into counterpoised beakers, and weighed as a check on the burette reading. Several precipitations of the barium in the form of sulphate were made, both in the presence of free hydrochloric acid and in neutral solution, and the mean of closely agreeing determinations was taken as the value of the standard solution. The mode of procedure in the testing was simple and may be outlined as follows:—Into a counterpoised beaker a definite amount of the standardized solution of barium nitrate was drawn and the weight taken as before described, the amount of nitric acid to be used was then added, and the whole volume brought up to 90 cm^3 by the addition of water. This acid solution was then brought to the boiling point and 10 cm^3 of the dilute sulphuric acid added, and the whole was allowed to stand for the length of time shown by the table before filtering on asbestos, igniting and weighing. It will be seen that the total volume of liquid taken in each determination was uniformly 100 cm^3, the percentage of acid by volume being thus easily regulated. In no case did the amount of barium salt present exceed 0·4 gm. considered as the sulphate, and consequently the uniform amount of 10 cm^3 of dilute (1:4 by volume) sulphuric acid employed was always enough to assure the excess which Fresenius* has shown to be necessary in the precipitation of barium as the sulphate in the presence of hydrochloric acid. By reference to Series I it is evident that in the presence of five per cent of nitric acid very little solvent action is shown, and it appears also that the sulphate may be safely filtered after an hour's time. In the presence of ten to fifteen per cent of the acid the solvent effect is very small when the solution is allowed to stand six hours or more. With twenty to twenty-five per cent of acid present we find the solubility to be slightly increased, but even then the average loss is less than 0·001 grm.

* Zeitschr. f. anal. Chem., xxx, 455.

SERIES I.

	$BaSO_4$ equivalent to $Ba(NO_3)_2$ taken.	$BaSO_4$ found.	Error in terms of $BaSO_4$.	Averages.	Time between precipitation and filtration.	Per cent by volume of strong HNO_3.	Total volume.
	grm.	grm.	grm.	grm.	hours.		cm^3
(1)	0·2540	0·2336	0·0004 —		12	5	100
(2)	0·2489	0·2483	0·0006 —		"	"	"
(3)	0·2495	0·2489	0·0006 —	0·0006 —	"	"	"
(4)	0·2492	0·2482	0·0010 —		"	"	"
(5)	0·2486	0·2483	0·0003 —		6	"	"
(6)	0·2490	0·2490	0·0000	0·0002 —	"	"	"
(7)	0·2555	0·2546	0·0009 —		1	"	"
(8)	0·2538	0·2534	0·0004 —	0·0006 —	"	"	"
(9)	0·4067	0·4057	0·0010 —		12	10	"
(10)	0·2540	0·2533	0·0007 —		"	"	"
(11)	0·2492	0·2489	0·0003 —	0·0006 —	"	"	"
(12)	0·2493	0·2488	0·0005 —		"	"	"
(13)	0·2494	0·2488	0·0006 —		"	"	"
(14)	0·2492	0·2492	0·0000		6	"	"
(15)	0·2490	0·2489	0·0001 —	0·0002 —	"	"	"
(16)	0·2489	0·2484	0·0005 —		"	"	"
(17)	0·2540	0·2524	0·0016 —	0·0016 —	1	"	"
(18)	0·2529	0·2515	0·0014 —		12	15	100
(19)	0·2534	0·2522	0·0012 —		"	"	"
(20)	0·2533	0·2531	0·0002 —		"	"	"
(21)	0·2538	0·2532	0·0006 —	0·0007 —	"	"	"
(22)	0·2497	0·2490	0·0007 —		"	"	"
(23)	0·2489	0·2487	0·0002 —		"	"	"
(24)	0·2542	0·2528	0·0014 —		6	"	"
(25)	0·2486	0·2486	0·0000	0·0006 —	"	"	"
(26)	0·2492	0·2487	0·0005 —		"	"	"
(27)	0·2547	0·2532	0·0015 —	0·0015 —	"	"	"
(28)	0·2489	0·2478	0·0011 —		12	20	"
(29)	0·2486	0·2475	0·0011 —		"	"	"
(30)	0·2548	0·2546	0·0002 —	0·0008 —	"	"	"
(31)	0·2548	0·2542	0·0006 —		"	"	"
(32)	0·2496	0·2486	0·0010 —		"	"	"
(33)	0·2539	0·2527	0·0012 —		6	"	"
(34)	0·2488	0·2475	0·0013 —	0·0008 —	"	"	"
(35)	0·2497	0·2497	0·0000		"	"	"
(36)	0·2486	0·2477	0·0009 —		12	25	"
(37)	0·2491	0·2490	0·0001 —		"	"	"
(38)	0·2494	0·2484	0·0010 —		"	"	"
(39)	0·2538	0·2535	0·0003 —	0·0008 —	"	"	"
(40)	0·2492	0·2484	0·0008 —		"	"	"
(41)	0·2487	0·2471	0·0016 —		"	"	"
(42)	0·3414	0·3407	0·0007 —		"	"	"
(43)	0·2489	0·2481	0·0008 —	0·0007 —	6	"	"
(44)	0·2485	0·2478	0·0007 —		"	"	"

Having shown that free nitric acid even though present in considerable amount has only a slight solvent influence upon barium sulphate it seemed interesting to try the effect of the combination of nitric and hydrochloric acids mixed in the proportion to form aqua regia ($3HCl : 1HNO_3$). The experiments

recorded in Series II show that aqua regia has even less effect as a solvent than nitric acid alone. In fact it seems to act like hydrochloric acid alone, which practically has no solvent effect, as shown by Dr. Mar's work previously cited.

SERIES II.

	$BaSO_4$ equivalent to $Ba(NO_3)_2$ taken.	$BaSO_4$ found.	Error in terms of $BaSO_4$.	Averages.	Time between precipitation and filtration.	Per cent by volume of strong aqua regia.	Total volume.
	grm.	grm.	grm.	grm.	hours.	(3HCl : 1HNO$_3$).	cm^3
(1)	0·2539	0·2534	0·0005 −		12	5	100
(2)	0·2540	0·2538	0·0002 −	0·0002 −	"	"	"
(3)	0·2490	0·2490	0·0000		"	"	"
(4)	0·2491	0·2492	0·0001 +		"	"	"
(5)	0·2488	0·2484	0·0004 −	0·0001 −	6	"	"
(6)	0·3419	0·3421	0·0002 +		"	"	"
(7)	0·2491	0·2487	0·0004 −		12	10	"
(8)	0·2486	0·2482	0·0004 −	0·0006 −	"	"	"
(9)	0·2549	0·2539	0 0010 −		"	"	"
(10)	0·2543	0·2538	0·0005 −		"	"	"
(11)	0·2487	0·2485	0·0002 −	0·0002 −	6	"	"
(12)	0·3416	0·3415	0·0001 −		"	"	"
(13)	0·3417	0·3420	0·0003 +	0·0003 +	1	"	"
(14)	0·2547	0·2544	0·0003 −		12	15	"
(15)	0·2492	0·2492	0·0000	0·0003 −	"	"	"
(16)	0·2489	0·2479	0 0010 −		"	"	"
(17)	0·3412	0·3412	0·0000		"	"	"
(18)	0·3418	0·3417	0·0001 −	0·0001 −	6	"	"
(19)	0·3413	0·3412	0·0001 −		"	"	"
(20)	0·3411	0·3402	0·0009 −	0·0009 −	1	"	"
(21)	0·2492	0·2484	0·0008 −		12	20	"
(22)	0·2486	0·2480	0·0006 −	0·0005 −	"	"	"
(23)	0·2491	0·2485	0·0006 −		"	"	"
(24)	0·3412	0·3411	0·0001 −		"	"	"
(25)	0·3417	0·3418	0·0001 +	0·0000	6	"	"
(26)	0·3417	0·3417	0·0000		"	"	"
(27)	0·3414	0·3404	0·0010 −	0·0010 −	1	"	"
(28)	0·2491	0·2485	0·0006 −		12	25	"
(29)	0·1701	0·1697	0 0004 −	0·0003 −	"	"	"
(30)	0·1708	0·1705	0·0003 −		"	"	"
(31)	0·1710	0·1710	0·0000		"	"	"
(32)	0 3415	0·3410	0·0005 −	0·0003 −	6	"	"
(33)	0·3418	0·3418	0·0000		"	"	"
(34)	0 3412	0·3405	0·0007 −	0·0007 −	1	"	"

In this connection I append the results of a few experiments made to determine the effect of the presence of a considerable amount of free nitric acid, on the precipitations of barium as sulphate in cases where certain substances are present which under ordinary conditions tend to hold up the precipitate. Fresenius* has demonstrated this property in the case of ammonium nitrate, Scheerer and Rube,† have shown that

* Zeitschr. f. anal. Chem., ix, 62. † Erdm., Jour. prakt. Chem., lxxv, 113–116.

metaphosphoric acid acts similarly, and Spiller* notes the same general effect where alkaline citrates are present. Series III shows the results obtained by precipitating definite portions of the standard solution of barium nitrate in the presence of stated amounts of the substances just mentioned. The total volume in every case was 100 cm^3, the amount of dilute sulphuric acid used 10 cm^3, and the time between precipitation and filtration twelve hours. Upon filtering, igniting and weighing the barium sulphate an excess of weight, due undoubtedly to contamination of the precipitate, was found. It became necessary, therefore, to purify the precipitate as first weighed in order to determine whether all the barium was actually precipitated or whether a partial loss was covered by the amount of included impurity. The method of purification employed was that successfully applied by Dr. Mar in the work previously mentioned. The contaminated sulphate, collected on paper and treated according to the familiar method (on account of the difficulty attending the complete removal of the precipitate from asbestos for purposes of purification), was dissolved in warm concentrated sulphuric acid, and evaporated quickly and without spattering by means of the Hempel burner, the barium sulphate being left after this treatment in coarse granular crystals. The crystallized sulphate was warmed with a little water containing a drop of sulphuric acid, filtered upon an asbestos felt contained in a perforated platinum crucible, the crucible and felt having been previously ignited and weighed.

SERIES III.

Impurity present to the amount of 5 grm.	$BaSO_4$ equivalent to $Ba(NO_3)_2$ taken.	Apparent amount of $BaSO_4$ found.	$BaSO_4$ after purification.	Error after purification.	Percentage of strong HNO_3 by volume.
	grm.	grm	grm.	grm.	
(1) Ammonium nitrate	0·1710	0·1800	0·1702	0·0008—	10
(2) " "	0·3415	0·3440	0·3410	0·0005—	"
(3) " citrate	0·3412	0·3442	0·3407	0·0005—	"
(4) Sodium "	0·1360	0·1730	0·1366	0·0006+	"
(5) Metaphosphoric acid	0·3461	0·3511	0·3470	0·0009+	"

The results show that in the presence of nitric acid amounting to one tenth by volume of the entire liquid these salts exert no apparent interference with the precipitation of the barium.

The entire work would seem to show that the presence of an excess of nitric acid or aqua regia amounting to ten per cent by volume of the liquid treated is not only not to be avoided in estimating barium as the sulphate, but is actually beneficial. Ordinarily the advantage is found in the tendency

* Chem. News, viii, 280–281.

of the precipitate to fall coarsely crystalline under the conditions. In certain special cases in which certain substances mentioned, which would otherwise exert solvent action, are present the precipitation is made complete. The contaminating effect of such substances when complete precipitation is induced may be corrected by dissolving the precipitate in sulphuric acid and recrystallizing by evaporation.

ART. XLIX.—*On a Rose-colored Lime- and- Alumina-bearing Variety of Talc;* by WM. H. HOBBS, Madison, Wis.

THE crystalline dolomite of the vicinity of Canaan, Conn., is well known as a locality for white pyroxene and white and pale green tremolite. Some of this tremolite has recently been shown to be pseudomorphic to the white pyroxene.* Small amounts of quartz and colorless mica, and isolated crystals of pyrite, are present in the rock at many localities, and veins of calcite are occasionally met. Except near the boundaries of the horizon, where the rock passes by gradations toward a gneiss or schist, these are the only common minerals. Phlogopite I have found in clear brown scales a millimeter or more in diameter on the road running south from Rattlesnake Hill. The numerous openings which are made in the dolomite for supplying the lime-kilns of the vicinity, furnish opportunities for the discovery of any less common constituents that may be included in the rock. Mr. J. S. Adam, former analyst of the Barnum and Richardson Company of Lime Rock, has in his mineral collection at Canaan, several minerals of this character which have not been carefully studied. I am under obligations to him for the material which is here described. It was met with in the Adam Quarry which is located a mile southeast of the village of Canaan. The specimens given me are enclosed in the white crystalline dolomite whose grains average two millimeters in diameter.† Scattered through the dolomite

* Wm. H. Hobbs, Notes on some Pseudomorphs from the Taconic Region, Am. Geol., x, 44 (1892).

† I am permitted by Mr. Adam to publish analyses by him of the dolomite of the vicinity, which show it to contain calcium and magnesium carbonates in the proportions of normal dolomite:

	Canaan Lime Company's Quarry. Granular.	Cleavage Pieces.	Calculated for $CaCO_3 . MgCO_3$.
$CaCO_3$	52·62	54·40	54·35
$MgCO_3$	46·25	45·12	45·65
Fe_2O_3, Al_2O_3	0 24	0·25	
Insoluble residue	0·17	0·08	
	99 28	99·85	100·00

are simple pentagonal dodecahedrons of pyrite about a millimeter in diameter, which are colored brown from superficial alteration to limonite. On lines evidently corresponding to fracture planes in the rock, is developed a talcose mineral. Other fracture lines are occupied by vein dolomite, one cleavage surface extending several centimeters. In one of the specimens the talcose mineral has a deep rose color, somewhat deeper than that of the margarite from Chester, Mass. In the other specimen the color is white or nearly so, but Mr. Adam informed me that when found it had the same rose hue as the first mentioned specimen. The rose color has faded through exposure to the light, resembling in this respect rose quartz.

The scales of this talcose mineral lie with entire lack of any regular orientation, completely filling the fissure. Scales one-half a centimeter across can be obtained having roughly hexagonal outlines, but which are too poor for accurate measurement. They are very flexible but entirely inelastic. They have the softness and unctuous feel of ordinary talc. After treatment with dilute hydrochloric acid to remove any possible trace of calcite, nearly a gram of the material gave a specific gravity of 2·86 by determination with the pyknometer. In the closed tube the powdered mineral yields considerable water. Ignited before the blowpipe it resembles talc in exfoliating, whitening and glowing intensely. It is, however, much more fusible, falling below 5 in v. Kobell's scale. It is also more readily decomposable than common talc. When digested for only a short time in hydrochloric acid, the solution yields a considerable amount of alumina and calcium.

Between crossed nicols in convergent light, scales of the mineral show a negative bisectrix perpendicular to the plane of cleavage. The optical angle, which is very small, lies in the plane perpendicular to one of the bounding planes, and also perpendicular to a side of the hexagon of the percussion figure. It therefore corresponds to a mica of the first class. $2E$ was measured in sodium light as $15\frac{1}{2}°$.

I am indebted to my friend, Mr. Louis Kahlenberg of the University of Wisconsin, for a chemical analysis of this mineral. His results are given below in the first column. In the last column is given the theoretical composition of ordinary talc:

			Calculated for $H_2Mg_3Si_4O_{12}$
SiO_2	61·48	64·52	63·52
Al_2O_3	3·04		
MgO	25·54	30·50	31·72
CaO	4·19		
FeO	0·77		
MnO	trace		
H_2O	5·54		4·76
	100·56		100·00

The mineral contains no nickel.

The analysis corresponds to a normal talc in which the magnesia is in part replaced by lime and the silica by alumina. The trace of manganese accounts for the rose color of the mineral which is lost on exposure to sunlight. The large amount of lime present is doubtless the cause of the unusual fusibility and decomposability by acids. Small amounts of lime in talc are not altogether unusual, though I have been unable to learn of but three analyses of the mineral, which have yielded more than one per cent of lime. These are given by Hintze in the list of sixty-seven analyses of talc printed in his Handbuch der Mineralogie.* The three occurrences referred to are Plaben, Bohemia (CaO, 1·09 per cent); Bergen Hill, New Jersey (CaO, 1·41 per cent); and Campo Longo (?), Tessin (CaO, 3·70 per cent.) The presence of alumina in talc would not seem to be so unusual, since the same list includes four occurrences of talc characterized by as large an amount of alumina as the Canaan mineral. They are, Plaben, Bohemia (Al_2O_3, 3·27 per cent); Gasteinthal, Salzburg (Al_2O_3, 5·37 per cent); Mainland, Shetland Isles (Al_2O_3, 4·14 per cent); and Fahlun, Sweden (Al_2O_3, 4·69 per cent). No occurrence is mentioned by Hintze which like the Canaan mineral contains considerable amounts of both alumina and lime.

As regards the color of the mineral, it seems to be altogether exceptional. Nearly all the text-books mention a rose talc from Cooptown in Harford County, Maryland, but I am informed by Dr. G. H. Williams that the authority for this is a statement made by Tyson as long ago as 1837, the mineral being not talc but kaemmererite or rhodochrome. Hintze mentions in his Handbuch† beside the Cooptown locality, two others where rose-colored talc occurs, viz: in granite at Fischbach near Hirschberg, Silesia,‡ and with magnesite in clay slate at

* Leipzig, 1892, pp. 824–6.

† Loc. cit., pp. 819–821.

‡ Traube, Min. Schles., 1888, 224.

Wald in Styria.* The original reference to the first has not been accessible to me, and the second contains no mention of the mineral's properties.

The Canaan mineral is thus shown to belong to the talc family by its chemical composition as well as by most of its physical and optical properties. That it is a somewhat distinct variety is shown by its high percentages of lime and alumina, by its low fusibility and easy decomposability by acid, and by its exceptional rose color.

University of Wisconsin.

Art. L.—*The Magothy Formation of Northeastern Maryland;* by N. H. Darton, U. S. Geological Survey.

Contents: *Introductory. General relations. The Magothy Formation.* Distribution. General features. East of Chesapeake Bay. Magothy River region. Severn River region. Odenton region. Patuxent River region. Original extent and thickness. Definition. Synonomy. Economic Geology. History.

Introductory.

In this paper there is described an arenaceous formation not heretofore discriminated, lying between the Potomac and Severn formations in the upper Chesapeake Bay region.

Up to 1891, when I published my memoir on the Mesozoic and Cenozoic formations of eastern Virginia and Maryland,† I had given but little attention to the details of the geology of northeastern Maryland and believed that there was but one physical gap between the Potomac and Severn formations. Later studies in this region have led to the discovery that a series of sands and brown sandstones which I formerly supposed to be a local upper member of the Potomac formation, is separated from it by a continuous erosion plane, and constitutes a distinct formation.

As this formation is excellently exposed on the Magothy River, and partly for want of a better name it has been designated the Magothy formation. The general features of its distribution in Maryland are shown on the accompanying map. In the course of a few weeks a geological map of Maryland will be published by the State on which the lower boundary of this formation will be represented on a larger scale, and later its distribution west of Chesapeake Bay will be shown in detail on atlas sheets now in course of publication by the U. S.

* Rumpf, Ueber krystallisirte Magnesite aus den nordöstlichen Alpen, Tschermak's Min. Mittheil., 1873, p. 271.

† Geological Society of America, Bull., vol. ii, pp. 431–450, pl. 16.

Geological Survey. Finally, I will describe the formation more fully in a Monograph on the Geology of the Chesapeake Bay region now in preparation.

General Relations.

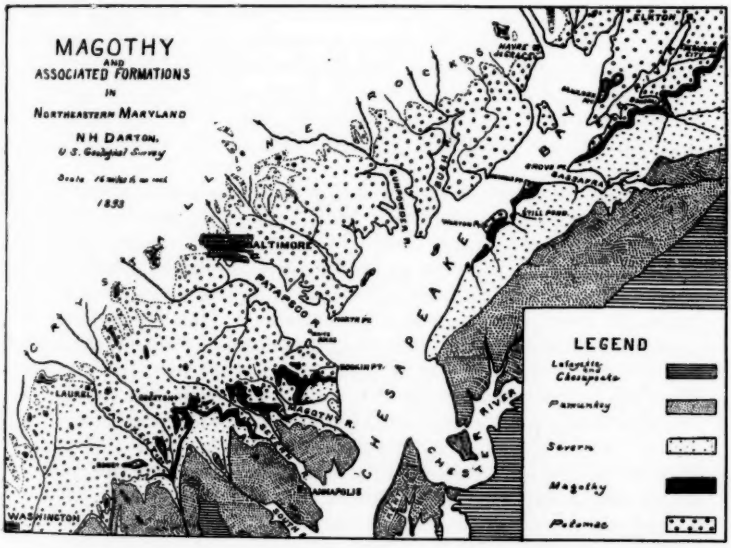
The coastal plain of eastern Maryland is underlain by a series of later Mesozoic to Pleistocene deposits lying on an east-sloping floor of crystalline rocks. These deposits are widely extended sheets of sands, clays, and marls inclined and thickening to the southeast and separated into formations by erosion breaks. In the following table there is given a list of these formations and breaks, an explanation of their age and a brief description of their general characters:

	Formation.	Characters.	Paleontologic position.
Pleistocene.	*Columbia*	Loams, sands, and gravels. On terraces.	
		Erosion interval. Development of outlines of present topography.	———
Neocene.	*Lafayette*	Gravels, sands, and loams	Pliocene?
		Erosion interval. Base levelling over Coastal plain and westward	———
	Chesapeake	Sands, clays, infusorial earths, and marls	Miocene.
Eocene.		Erosion interval, planing of surfaces of preceding deposits	———
	Pamunkey	Glauconitic marls and sands	Eocene.
Cretaceous.		Erosion interval, planing of surface of Severn and Potomac formations	———
	Severn	Black, argillaceous sands, mainly	Cretaceous.
		Erosion interval, planing of surface of Magothy and Potomac formations	Cretaceous.
	Magothy	White sands and brown sandstones, also gravels	Cretaceous.
		Erosion interval, planing of surface of Potomac formation	Cretaceous.
	Potomac	Clays and sands, also gravels and sandstones	Early Cretaceous.
		Great erosional and stratigraphic break following Jura-Trias deposition.	

The Potomac formation lies directly on the crystalline rocks and outcrops over a wide belt eastward. Its western border extends westward on the ridges and the crystalline rocks extend eastward in the intervening depressions. It is succeeded eastward by the younger formations outcropping in succession in irregular northeast and southwest belts which are deflected westward of the ridges and eastward down the de-

pressions. The Lafayette and Chesapeake formations form a partial exception to this general statement for they overlap the other formations in some localities, and their western extension is now represented by small outliers occurring mainly in the higher lands to the northwest. The Columbia terraces extend across the other formations from the crystalline rocks in the depressions westward, to the Lafayette in the lowlands far to southeastward.

In southern Maryland the typical Coastal Plain topography of the south Atlantic region prevails, an elevated east-sloping plain capped by Lafayette formation, and holding sharply depressed drainage basins lined with low Columbia terraces which extend eastward into a wide low belt adjoining the ocean. This east-sloping Lafayette plain has also a gradual tilt northward and with increasing altitude it is more and more widely eroded. Near the latitude of Washington it finally terminates, except for a few small outliers, and through northeastern Maryland the region west of the bay, although still elevated, is rolling in contour in the higher lands and occupied by areas of Columbia terraces in the moderately elevated and low districts. The entire country east of Chesapeake Bay is a Columbia terrace relatively low throughout but gradually increasing in altitude to the north and northwest.



The Magothy Formation.

Distribution.—As is shown on the accompanying map the Magothy formation extends from the Delaware line to a point just southwest of Bowie, where it disappears in the overlap of the Severn onto the Potomac formation. I have not traced its eastward continuation through Delaware but the formation undoubtedly extends some distance at least, probably included in the sand marls described by Chester as the base of the glauconitic series.

East of Chesapeake Bay the Magothy formation extends in a nearly straight line from near Chesapeake City to below Worten's Point and outcrops below the Columbia deposits in the face of river and bay bluffs and in stream cuts. Its range of altitude is not great except in the outlying area of Maulden Mountain where it lies in greater part above one hundred feet above tide. Its dip is to the east-southeast at from 20 to 30 feet per mile.

West of the bay the formation begins a short ways below Bodkin Point at the mouth of the Patapsco, and crosses the rolling country and three or four intersecting valleys, south-westward to its termination. Its inclination of from 30 to 40 feet per mile carries it far westward up the long slopes of the ridges in irregular sheets and outliers but it descends below the Severn formation at tide level eastward along a line essentially continuous with its course on the eastern shore of the bay. The altitudes attained in the ridges westward are 130 feet on the neck between the Magothy and Patapsco Rivers, 240 feet in a far western outlier near Severn Station on the Magothy-Severn divide, 250 feet east of Odenton, 160 feet between the forks of the Patuxent and 190 feet on the ridge just east of Bowie.

General Features.—The Magothy formation consists mainly of white and buff sands with local beds of brown sandstone, and limonitic streakings both in plates and discolorations. Southwestward it becomes gravelly for some distance and some portions are locally lithified into loose conglomerates or harder, more or less pebbly, brown sandstones. The ferrugination which gives rise to the brown sandstones is by no means confined in this region to the Magothy formation for brown sandstone and limonitic masses and crusts are scattered locally in the Potomac, Pamunkey and Columbia formations and also but more rarely in the Severn, Chesapeake and Lafayette formations. The sands of the Magothy formation are moderately coarse and at some localities they are very coarse. They consist of quartz grains which vary in shape from rounded to subangular with a greater or less admixture of angular grains.

They lie loosely—a characteristic feature, in beds usually quite thin and regular but locally cross-bedded, sometimes to an extreme degree. The thickness varies from 10 to 30 feet but about 15 feet is the usual amount. An admixture of carbonaceous materials is often present in the form of grains but several thin beds and interbeddings of lignite have been observed. A few thin streaks of pale gray clays occur interbedded in the formation in the Bohemia River region.

The unconformities between the Magothy and Potomac below and with the Severn above are planes of erosion everywhere distinct and participating in the general southeastward inclination of the Coastal plain deposits.

East of Chesapeake Bay.—The northeasternmost exposures of the Magothy formation, which I have observed, are in the vicinity of Chesapeake City near the eastern terminus of the Chesapeake and Delaware canal. The cuts of the canal begin about two miles east of Chesapeake City and are in the marls and black sands of the Severn formation of which they afford a superb exposure. At the western end of these cuts and in several small stream depressions in the vicinity there are showings of the Magothy sands overlain by the black Severn beds. The sands are white, gray, and buff, streaked irregularly with light brown. The entire thickness of the formation was not observed in this region but in one exposure twenty feet of its sands were seen, capped by weathered, gray-brown Severn beds along an undulating plane of unconformity.

Between Chesapeake City and Bohemia Creek small exposures of Magothy beds are frequent in the deeper stream cuts. They are overlain directly by the Columbia gravels and loams westward, and the feather-edge of the Severn sands eastward.

On the south shore of Bohemia Creek near its mouth there is a long, high bluff in which the Magothy and adjacent formations are finely exposed. The basal beds are typical Potomac variegated clays, pink and red predominating, but in part buff and dark lead color. These clays extend to an altitude of about 30 feet at the western end of the bluff but this upper surface dips gently eastward and finally sinks below the water in about a mile. This upper surface is an undulating plane presenting no marked irregularities of contour and it is clearly a product of aqueous erosion. It is overlain by the Magothy sands which have a thickness varying from fifteen to twenty-five feet. These sands are mainly white or light gray but in places they are stained with buff and pinkish streakings. The materials are moderately coarse quartz grains quite uniform in size, rounded or subangular in greater part and lying loosely compacted in thin beds with but little cross-bedding. Near their base they sometimes contain a

small amount of clay fleckings and intermixture, derived from the subjacent clay formation, and discontinues streaks of limonite. Towards the western end of the bluffs they include two elongated lenses of tough, laminated, gray clay. The lower mass is near the base of the formation and is about six feet thick; the upper one is near the top and has a maximum thickness of three feet. These clay streaks merge into the adjoining sands, but the transition is quite abrupt at most points. Overlying the Magothy formation eastward is a thin wedge of weathered Severn sands separated by an east dipping erosion plane similar to the one below. The Severn beds attain a thickness of 15 feet at the eastern end of the bluffs but are cut out westward by an overlap of the overlying Columbia formation onto the Magothy beds. The Severn beds are dark gray, argillaceous, carbonaceous, fine, laminated sands with some portions less argillaceous slightly glauconitic, more massive and lighter gray in color with buff mottlings. They are sharply contrasted from the Magothy beds and even without the separating unconformity could never be classed with them. The Columbia capping on these bluffs has a thickness of from four to seven feet. It consists of a basal bed of pebbles, bowlders and slabs with local beds of conglomerate and an upper bed of red-brown to buff, columnar loam with a few scattered pebbles.

The next notable Magothy exposures southward are in the long high bluffs extending north from Grove Point. Towards the point the bluffs are of Severn beds overlain by Columbia deposits both superbly exposed.* About 1000 yards north of the point the Magothy formation comes up on a low southern dip and soon attains prominence in the bluffs in which it continues to the end. The formation consists of coarse, loosely compacted, cross-bedded gray sands with irregular masses and streaks of brown sandstone and sandy limonite. The erosion plane separating the Severn formation is well exposed and is seen to be less regular in contour than usual. The ferrugination of the Magothy beds is here very irregular and predominates near the summit. Below are many scattered masses consisting of reticulated plates and tubes of sandy limonite, some of which are several feet in length and as much as a yard in thickness.

On the peninsula between Elk River and the head of Chesapeake Bay there is a high ridge on which there remains an outlier of Magothy with overlying Severn formation constitut-

*Detailed descriptions of the Columbia formation in these and many other bluffs in this region are given by McGee in a memoir on "The Geology of the head of Chesapeake Bay. U. S. Geol. Survey, Seventh annual report of the Director, pp. 537–646, pls. 1888.

ing two local eminences known as Maulden Mountain and Bull Mountain. The western sides of these so-called mountains are cut by the bay giving rise to very prominent bare bluffs 120 to 130 feet in height, in which the Potomac and Magothy formations are well exposed. The Potomac beds in this region are the typical variegated clays in which pink and buff colors predominate but some reds and purples also occur. In the upper part of the Potomac here there is a local bed of white sand with more or less pink clay admixture which extends for some distance along the bluff. The Magothy beds lie on the usual erosion plane and are distinct from the Potomac sands and clays below. They consist mainly of coarse, loose, pure sands, regularly bedded except at a few points where cross-bedding was observed. Several thin, local streaks of clay are included and many large masses of brown sandstone. Loose masses of this sandstone, in part pebbly, are prominent in sandy areas between the higher portions of the ridge. The Severn outliers are of weathered beds, consisting of dark gray, fine, argillaceous sands below and more arenaceous, gray buff members above, attaining in all a thickness of about forty feet. Their entire separateness from the Magothy beds is exhibited in several exposures. The higher summits about Maulden Mountain are from 150 to 180 feet above tide level, and are capped by outliers of Columbia of the high level series.

The high bluffs along the south shore of the Sassafras River near its mouth, expose the Severn beds in great force. Approaching Howell's Point the gentle southeast dip brings up the Magothy beds which soon displace the Severn formation, and extend westward nearly to the Point. They are the usual moderately coarse sands but vary in color from pink to flesh colored in greater part, with light brown streakings locally. Their thickness is about twenty-five feet. They are loosely bedded, with some cross-bedding. The underlying Potomac beds come up in turn about 600 yards west of the first appearance of the Magothy beds and the two formations continue to the end of the bluffs, a short distance westward. The Potomac beds are typical variegated clays comprising white, buff, pink, red, and dark lead colors. Their surface is quite uneven and the clays are separated from the Magothy sands by a thin, interrupted, layer of impure limonite and coarse sand with a few scattered quartz pebbles. The bluff is capped with Columbia members which constitute about two-thirds of its height.

Howell's Point is a tide marsh area, but a short distance south the bluffs again extend to the bay shore and thence continue to Still Pond. The Columbia formation extends down to tide level for considerable distances in these bluffs but the upper part of the Magothy beds is well exposed in the

intervals. The formation consists of the usual coarse, loosely bedded sands generally white but in places stained buff or pinkish. Several short thin streaks of light colored clays occur and a few thin, discontinuous layers of ironstone. In the base of the overlying Columbia are several masses of coarse brown sandstones and conglomerate but they are sharply separated from the Magothy beds. Near the entrance to Still Pond a change of trend in the bluffs to southeast, carries them into the Severn belt, bringing in Severn beds between the Columbia and Magothy formations. In the next half mile the dip carries the Magothy formation below tide level and soon after, the Columbia deposits come down to the base of the bluff. The Severn beds in the exposure are weathered at their base to gray and lead colored clays with sandy layers; an unusual character. Higher up they are the typical black argillaceous, carbonaceous sands, covered superficially with green and gray sulphurous incrustations from decomposing pyrite, a common feature at this region. Their relations to the Magothy beds are particularly well exposed here and the gently undulating erosion plane extends along the bluff in plain view for a considerable distance. At their southeasternmost exposure in the bluff the Magothy sands are steeply crossbedded, some of the bedding planes having an inclination of 25°.

South of Still Pond there are no notable exposures of Magothy beds, the prominent bluff on Worton Point lying west of their outcrop belt and exposing only Potomac and Columbia deposits.

Magothy River region.—The Magothy formation appears first on the western shore of Chesapeake Bay on the bay shore 1½ miles south of Bodkin Point. The exposure is in a low bluff and consists of an irregular mass of brown sandstone in buff sands in all about fifteen feet thick of which the greater part is sandstone. It is underlain by typical yellow and pink Potomac clays along an irregular plane and dips below weathered, but unmistakeable Severn beds exposed a short distance south but not in contact.

On the north side of the Magothy River the formation and its relations are well exposed in a small side inlet, Broad Creek, about three miles above the mouth of the river. To the east on Gibson, and Dobbin islands and in the adjoining higher lands notably Eagle Hill the Severn beds are extensively exposed with all their usual characteristics. To the west up the river the underlying Potomac clays and sands comes out. In the inlet above referred to the contact with the Potomac formation is exhibited in a long low bank and the line of unconformity is seen to be unusually irregularly and strikingly distinct. The Magothy beds are the usual coarse gray, loosely

bedded sands containing more or less brown sandstone. The Potomac formation here is a densely packed, moderately fine, "sharp" sand with more or less disseminated clay particles, a member which is first seen in this vicinity and extends for about twenty miles southwestward. This Potomac member merits some special description here on account of its unusual characters, relations to the Magothy formation and some misapprehensions which exist regarding it. Its sands grade into and give place to white and pink sandy clays at some localities but they are usually characterized by their purity and extreme compactness. At some points they are lithified in greater or less part into white or gray sandstones or quartzites, and less frequently brown sandstone. This sandstone constitutes the "White Rocks" out in the Patapsco River near its mouth and there are a number of other occurrences of it. This arenaceous Potomac member is, I suppose, the upper part of the "Albirupean formation" of Uhler, but as it grades into typical Potomac clays and sands and is unquestionably not separated by any stratigraphic break I see no grounds for its separation as a distinct formation.*

On the neck between the Magothy and Patapsco Rivers the sands and brown sandstones of the Magothy formation extend inland for several miles covering the higher areas and capping several small outlying knobs.

Severn River region.—In the bluffs along the north shore of the Severn River at Round Bay and for some distance above, the Magothy formation and its relations are finely exposed. Just south of the Round Bay hotel there is a bluff which with the steep slopes above expose 140 feet of beds from the top of the Magothy some distance up into the Pamunkey formation. The Pamunkey beds here are weathered to brown, buff and red sands with ferruginated masses, containing Eocene fossils. Lying unconformably below the Pamunkey formation are 90 to 100 feet of the black micaceous, argillaceous and carbonaceous sands of the Severn formation. Near the base of the bluff the base of the Severn beds is exposed for several yards lying unconformably on very coarse, white Magothy sands along an east-dipping plane extending to a few feet above water level.

In the next five hundred yards west these sands rise rapidly and some low bluffs exhibit a thickness of twelve feet with a

* The term Albirupean was proposed by P. R. Uhler in 1888 to the American Philosophical Society (see Proceedings, vol. xxv, page 42). The fossils exhibited and reputed to have been obtained from the "Albirupean" were shown by Heilprin and Lewis to be of Upper Silurian age and were probably fragments from the Columbia formation. Its taxonomy was never clearly defined and its author now includes under the name the greater part of the upper Potomac formation of Maryland, all the sand lenses in the Potomac from top to bottom, apparently, and I take it, the great Potomac series in Virginia.

thin capping of weathered Severn beds. The coarseness of the upper part of the Magothy is not so pronounced in this exposure and the sands for some distance below are of the usual moderately coarse, loosely bedded type. Near their base, thin, interbedded carbonaceous layers gradually come in and finally form an irregular lignitic layer with white sand streaks. Below this are irregular layers of brown sandstone two or three feet thick exposed along the beach.

In the next bluff up the river, Potomac, Magothy and Severn beds are exposed in a section thirty feet in height. The Severn caps the bluff to a thickness of from six to nine feet and consists of fine, argillaceous sands weathered to a gray-buff color. They lie on a very even but clearly defined erosion plane exposed for nearly a hundred feet along the bluff. The Magothy beds average twenty feet in thickness but are several feet thicker at several points. They consist of regularly bedded, loosely compacted, gray sands with light buff streaks and blotchings containing thin streaks of brown sandstone above, and large masses of brown sandstone below. They lie on a very uneven surface of the densely packed sands and clays which as before stated characterizes the upper part of the Potomac formation in this region. One of the most notable irregularities of this surface is an old channel four or five feet in depth in which the Magothy beds come down nearly to water level. The Potomac deposits lying next below the Magothy formation are very densely packed, gray sands, in part lithified. They also contain a short streak of carbonaceous materials. Below, they give place abruptly to a series of lenses of very tough pearl-gray sulphurous clay with sulphur crusts on its surface. Underlying this clay are several masses of sandstone which outcrop at the base of the bluff. A person unfamiliar with the complicated stratigraphic relations in the coastal plain formation would be puzzled by this exposure with its several exceptional features in the Potomac formation, and their apparent unconformities, and by the two horizons of brown sandstones.

Ascending the river the dip brings up in succession lower and lower beds which exhibit very plainly the true general relations. There are several bluffs on the north shore exposing the very compact sands and clays of the Potomac, unconformably overlain by the loosely bedded coarse, white Magothy sands here constituting the surface formation. In a bluff about a mile and a half above Round Bay the Potomac beds attain an elevation of twenty-two feet and are overlain by from eight to ten feet of Magothy sands. This exposure is the key to the horizon of the compact sands and gray sulphurous clays for they are finely exhibited, *grading* laterally and downward into looser white

sands with streaks of red and pink clay of the usual Potomac type. A short way west these sands are exceptionally pure and they are quarried for use in the arts but in the western part of the quarries and beyond they are seen to grade into variegated sandy clays and then pure clays of typical Potomac character. There can be no doubt of the Potomac age of these compact sands and clays lying immediately below the Magothy formation in the district.

North of the Severn River in this region the Magothy gray and buff sands with brown sandstone fragments cap the higher summits over a considerable area and at many points are seen lying on Potomac clays westward and the compact sand and clay member eastward. The northwesternmost Magothy exposure is a brown sandstone cap on a very small, shaly elevated knob a mile east by south from Severn station.

On the south side of the Severn River the banks are lower and present no notable Magothy exposures. In the slopes south ascending westward nearly to Odenton there are frequent outcrops in which are seen gray and buff sands with brown sandstone masses. They lie on a gentle undulating plane of unconformity with local irregularities, and dip southeastward at the usual rate of about thirty feet per mile.

Odenton Region.—In the hills east of Odenton the Magothy beds attain an elevation of 220 feet and cap the higher lands over an irregular area of considerable extent. They are overlain by several small outlying areas of weathered Severn beds westward and the northwestern edge of this formation extends along the eastern slopes of the Magothy hills.

In the southwestern extension of the Magothy formation the light colored sands give place to darker colored and coarser sediments in which brown sandstones, gravels and conglomerates prevail. The gravels are most conspicuous a mile and a half east of Odenton in the cuts of the Annapolis railroad, and on the adjoining hills. The relation to the Severn sands is plainly exposed in these cuts and at several points in stream and road cuts in their vicinity and southwestward. The gravels are more or less cemented into a loose conglomerate and intermixed with sand and brown sandstone. The aggregate thickness is variable but it amounts to 23 feet in the railroad cuts. Two and a half miles southeast of here towards Millersville in the cuts for the Drum Point railroad a somewhat greater thickness is seen of buff sand, and brown sandstone, in part sparingly pebbly. Typical Potomac clays and sands are exposed underlying the Magothy formation at many points in the Odenton region and the usual unconformity is always very distinct.

Patuxent River region.—South of Odenton the Magothy formation gradually thins but it extends to some distance beyond the Patuxent River before terminating.

In the ridge just east of Bowie and again on the ridge between the two forks of the Patuxent there are outliers of Magothy brown sandstones in turn capped by small areas of weathered Severn beds. The Potomac formation in the adjacent slopes are typical variegated clays in greater part, but there are also lenses of compact gray sands locally silicified to white quartzites.

The southwestern termination of the Magothy formation is not clearly exposed and the outcrops along the Patuxent are obscure. In the hills southwest of Bowie the Severn beds lie directly on Potomac clays and are themselves cut out at intervals westward by Pamunkey beds as far south as Washington.

The thinning may be due to an actual decrease in thickness of the original deposit or an overlap of its shore lines by a later formation, but it appears to have resulted from an increase southward of the erosion to which its surface was subjected in the interval preceding Severn deposition.

Original extent and thickness.—How far south the Magothy formation may have extended is not known, and as its surface has been eroded the original thickness is not determinable. The location of the northwestern shore line of the formation is not defined but it was probably very near the gravelly deposits extending from Bowie to beyond Odenton.

Definition.—The Magothy formation is a thin series of arenaceous deposits lying between the Potomac and Severn formations and separated from both by erosional unconformity and great dissimilarity of character. There are local unconformities at various horizons in the Potomac formation at the base of some of its sand lenses but these unconformities are due solely to current action and exist only within a restricted area. I have studied many of these Potomac sand lenses and found the sands grading laterally into clays or clays and sands and these merging downward across the horizon of unconformity into clays below. The unconformity at the base of the Magothy formation is clearly not of this character nor is the break at its summit, but both are in every way similar to the erosion planes which bound all the other members of the Coastal plain series.

The age and equivalence of Magothy formation is not known with any degree of precision but its stratigraphic position places it in the early Cretaceous. It contains plant remains at several localities notably in the lignitic members on

the Severn River at Round Bay, but they have not been studied.

The formation is not divisible into individual members, for the variations in character which it presents are local features not characterizing definite horizons.

Synonomy.—The Magothy formation has never before been discriminated or at least with any degree of definiteness. Mr. P. R. Uhler in his several papers* has referred more or less definitely to some of its features at several localities but he does not set forth its true relations. He has separated a member, which he terms "alternate sand series" beginning somewhere at this horizon and extending up into the Severn formation, but its definition is so vague and moreover so variable in each succeeding publication of his that the name cannot be adopted without confusion.

Economic geology.—The Magothy formation has not as yet yielded any great amount of economic products. Its sandstone members have been employed locally to some extent as building stone and its gravels are used for railroad ballast. Some portions of its sands are, I believe, sufficiently pure for use in the arts notably on the Magothy River and at several points on the bay shore south of Howell's Point.

History.—The Magothy formation is a product of littoral deposition following the uplift and erosion of the Potomac deposits. It represents a time when currents and beach action were sufficiently active to sort out moderately coarse sands and spread them in beds, regular where the currents were gentle, and crossed where currents were more powerful. A few thin lenses of clay indicate that slack waters existed locally and the gravels westward indicate proximity to a shore line. The materials were probably all derived from the Potomac formation and the shore line was located within the Potomac area throughout. The far eastward extension of the Magothy beds now deeply buried below the Severn deposits, undoubtedly consists of the finer sands and clays which were carried farther off shore before being deposited.

Magothy deposition was succeeded by a general uplift and erosion interval during which the surface of the Magothy deposit was planed off in greater or less measure and degradation of the Potomac surface westward was continued. This epoch was followed by Severn deposition.

* Maryland Acad. Sci. Trans., vol. i, 1888–1892.

ART. LI.—*On Electrical Oscillations of Low Frequency and their Resonance;* by M. I. PUPIN, Ph.D., Columbia College.

[Continued from page 334.]

PART II. THEORETICAL DISCUSSION WITH SPECIAL REFERENCE TO THE THEORY OF RISE OF POTENTIAL BY RESONANCE.

I. *Introduction.*

A very faithful mechanical picture of the periodically varying flow in an electrical circuit possessing *localized** capacity and self-induction is obtained by considering the motion of a torsional pendulum, that is a heavy bar, say of cylindrical form, suspended on a stiff elastic wire. The moment of inertia of the bar and the elasticity of the suspension wire correspond to the coefficient of self-induction and the capacity of the circuit. The frictional resistance of the air corresponds to ohmic resistance, internal friction in the bar and the elastic suspension correspond to magnetic and dielectric hysteresis; angular displacement of the torsional pendulum corresponds to the electrical charge of the condenser, and therefore torsional reaction of the suspension to difference of potential between the condenser plates. Angular velocity in the one case stands for the current in the other, kinetic energy for electrokinetic energy, potential energy of the torsional forces stands for the electrostatic energy of the condenser charge.

In slow mechanical vibrations the decrement of the kinetic energy is chiefly due to external and internal frictional resistances. But as the frequency of the vibration increases other losses causing this decrement become more prominent; so the losses due to radiation in form of sound waves. Similarly in electrical oscillations of very high frequency; the decrement of the electrokinetic energy due to radiation in form of electromagnetic waves becomes considerably larger than that due to dissipation in consequence of ohmic resistance, magnetic and dielectric hysteresis. The analogy, therefore, supplied by mechanical vibrations is by no means a poor guide in the study of *even very rapid* electrical oscillations. *For slow vibrations the analogy is very striking and instructive.* To return to the torsional pendulum:—

Let I = moment of inertia of the bar,
θ = angle of displacement at any moment.

* The term *localized* is employed to distinguish the circuits considered in this paper from those electrical circuits in which self-induction and capacity are more or less uniformly distributed over the whole circuit, as, for instance, in the case of a Herzian Resonator.

Let the torsional force be as ordinarily assumed proportional to angle of displacement and the frictional resistance to angular velocity. An impulse having set the pendulum in motion it is required to describe the motion. The differential equation of motion is obtained by writing down the symbolical statement of the principle of moments, viz:

Rate at which the moment of momentum about the line of suspension varies ..... = Moment of all the forces about the same line.

That is

$$-\frac{d}{dt}\left(\mathrm{I}\frac{d\theta}{dt}\right)=\alpha\frac{d\theta}{dt}+\beta\theta \quad \ldots\ldots \quad (1)$$

or

$$\mathrm{I}\frac{d^2\theta}{dt^2}+\alpha\frac{d\theta}{dt}+\beta\theta=0 \quad \ldots\ldots \quad (2)$$

Certain well known conditions being fulfilled the following integral is readily obtained:

$$\theta=\mathrm{A}e^{-\frac{\alpha}{2\mathrm{I}}t}\sin\frac{2\pi}{\mathrm{T}}t \quad (3)$$

where T = *natural period* of the pendulum $= \dfrac{2\pi}{\sqrt{\dfrac{\beta}{\mathrm{I}}-\dfrac{\alpha^2}{4\mathrm{I}^2}}}$

The arbitrary constant A depends on the energy of the impulse and can be easily determined by well known rules. When $\frac{\alpha^2}{4\mathrm{I}^2}$ is small in comparison to $\frac{\beta}{\mathrm{I}}$ then

$$\mathrm{T}=2\pi\sqrt{\mathrm{I}\cdot\frac{1}{\beta}} \quad \ldots\ldots \quad (4)$$

that is, *the natural period of the pendulum is independent of the frictional resistance.*

I venture to discuss briefly this rather familiar mechanical problem; for, the discussion seems to throw a strong light upon some of the electrical problems which form the subject of this paper.

Let T_1 = natural period calculated by (3)
T_2 = " " " " (4)

By a simple transformation it is easily shown that

$$\mathrm{T}_1=\mathrm{T}_2\left(1+\frac{1}{8\pi^2}r^2-\ldots+\ldots\right) \quad (5)$$

where $r = \dfrac{\frac{T_2}{2}\alpha}{L}$

= ratio (approx.) of frictional loss during any half period to the amplitude of the kinetic energy during the same half period. I shall call it the *dissipation ratio.*

It follows therefore that whenever the dissipation ratio is smaller than $\frac{1}{4}$ then T_2 differs from T_1 by less than $\frac{1}{10}$ of one per cent. But since on the other hand

$$e^{-\frac{R}{2L}t} = e^{-r\frac{2t}{T_2}}$$

It follows that when the dissipation ratio $r = \frac{1}{4}$ then the pendulum will be practically reduced to rest after 16 complete oscillations. *This simple calculation shows, therefore, that even in very damped oscillations the period can and in most cases will be practically independent of the frictional resistance.*

The following observations are too well understood to need a mathematical commentary:—*a.* If a periodically varying force is applied to a torsional pendulum the oscillations will be *free oscillations* if the period of the force is the same as the natural period of the pendulum, that is if the force and the pendulum are in *resonance* to each other. When this resonance does not exist the oscillations are forced.

b. Of two periodically varying forces of the same mean intensity the one which is in resonance with the pendulum will produce the largest maximum elongation. The maximum elongation is reached when the work done by the resonant force during a complete period is equal to the frictional losses during that time.

c. The torsional force of the suspension varies periodically, its period being the same as that of the impressed resonant force, but differing from it in phase by a quarter of a period. The *amplitude of the torsional force can be much larger than the amplitude of the impressed force, especially when the frictional resistances are small, the moment of inertia large and the oscillations rapid,* that is the torsional coefficient large. For in this case that part of the work of the impressed force which is stored up in the kinetic energy of the pendulum will become large before the maximum elongation has been reached. But since this large kinetic energy has to be stored up in the potential energy of the torsional forces once during each half oscillation it is evident that a large torsional force will be called into action. *The amplitude of the tor-*

sional force is evidently an accumulative effect of the impressed force, and can easily be made so large as to break the suspension. This is a complete analogy to the breaking down of condensers due to a great rise in potential produced by resonance described further below.

The analogy can be carried further by considering the motion of a torsional pendulum A which is acted upon by a periodically varying force F, not directly, but through another torsional pendulum B to which A is suitably connected. The study of the motion of this system under different conditions as regards resonance between A, B and F gives a complete mechanical picture of the electrical flow in an electrical system consisting of a primary and a secondary circuit, each circuit having localized self-induction and capacity, when a periodically varying e. m. f. acts upon the primary circuit. An analytical discussion of the motion of this mechanical system would lead far beyond the limits of this paper. It seems sufficient to point out, that the analysis is almost identical with the following mathematical discussion of the electrical flow in resonant circuits and that it is possible to imitate in a mechanical model most of the electrical effects discussed below, by properly constructed torsional pendulums connected to each other in a suitable manner.

II. *On the Natural Period of an Electrical Circuit Possessing Localized Capacity and Self-induction.*

The circuit consists of a coil, whose coefficient of self-induction is L henrys, connected in series to a condenser of capacity C farads. Let the ohmic resistance be R ohms. An electrical impulse having started the electrical flow it is required to describe the flow. Let Q be the positive charge of the condenser in coulombs, at any moment, then the differential equation of the flow is obtained by writing down a symbolical expression of the generalized form of Ohm's law (disregarding losses due to magnetic and dielectric hysteresis)

$$-\frac{d}{dt}\left(L\frac{dQ}{dt}\right)=R\frac{dQ}{dt}+\frac{1}{C}Q \quad \ldots \quad (1^a)$$

or

$$L\frac{d^2Q}{dt^2}+R\frac{dQ}{dt}+\frac{1}{C}Q=0 \quad \ldots \quad (2^a)$$

Comparing these equations to (1) and (2) we see that certain well known conditions being fulfilled the familiar integral first discussed by Sir W. Thomson, can be written down as follows:

$$Q = Ae^{-\frac{R}{2L}t} \sin\frac{2\pi}{T}t$$

where T = natural period of the circuit

$$= \frac{2\pi}{\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}}$$

When $\frac{R^2}{4L^2}$ is small in comparison to $\frac{1}{LC}$ then

$$T = 2\pi\sqrt{LC}$$

that is *the natural period of the circuit is independent of the ohmic resistance.*

To show that it is only under very exceptional circumstances that this condition is not fulfilled, I shall consider a circuit consisting of a large Bell telephone connected in series with a condenser of 1 microfarad capacity. The resistance of the telephone is 100 ohms, very large indeed, considering that its coefficient of self-induction is only about 0·5 henrys. Making this circuit a part of the secondary circuit of the small transformer excited by the electro-dynamic interrupter described in part I of this paper* it is found that the sound of the telephone is loudest when the frequency of the vibrator is about 225. The pitch of the sound is not sensibly altered by changing the resistance within very large limits; a result required by theory. For the period calculated from formula

$T = 2\pi\sqrt{LC}$ gives 224,4 vibrations per second.

Adding the correction given by formula (5) we get for the corrected period $T_1 = 224{,}9$ a difference of only about $\frac{1}{4}$ of one per cent. Since the dissipation ratio $r = \frac{1}{2{,}25}$ we get for the damping factor $e^{-\frac{1}{2{,}25}\frac{2t}{T}}$, that is to say the electrical oscillations would disappear almost completely after only 10 complete oscillations, which shows that the ohmic resistance produces a very strong damping and yet the period is practically independent of it.

In circuits consisting of well made coils with finely divided but split iron cores the dissipation ratio r is very small even for frequencies as low as 100 periods per second. The period, therefore, will be independent of the dissipation losses even if

* This Journal, April, 1893.

hysteresis and Foucault current-losses approach the order of magnitude of the losses due to ohmic resistance. The natural period of such circuits, especially when tuned up to a frequency of over 200 periods per second will be given *very accurately* by the formula

$$T=2\pi\sqrt{LC}$$

To such circuits only the following discussion refers.

III. *On the Electrical Flow in a Resonant Circuit.*

Let a simple harmonic e. m. f. of period T act upon a circuit having localized self-induction and capacity, coil and condenser being connected in series. By the generalized form of Ohm's law we have in the usual notation

$$L\frac{dx}{dt}+Rx+P=E\sin pt \qquad (6)$$

The integral obtained by well-known rules is

$$x=\frac{p\,CE}{\sqrt{(1-p^2CL)^2+p^2C^2R^2}}\sin(pt-\varphi) \qquad (7)$$

where

$$\tan\varphi=\frac{1-p^2CL}{pRC}$$

which can also be written

$$x=\frac{E}{\sqrt{p^2L_1^2+R^2}}\sin(pt+\varphi_1)$$

$$\tan\varphi_1=\frac{pL_1}{R}$$

The integral written in this last form shows, as Oliver Heaviside first pointed out, that a condenser of capacity C in series with a coil changes the impedance of the circuit in such a way as if the condenser had a negative coefficient of self-induction equal to $\frac{1}{p^2C}$.* It produces also a shifting of phase. *The impedance is reduced to ohmic resistance* when $L_1=0$ or $p^2LC=1$, that is when the period of the impressed e. m. f. is equal to the natural period of the circuit, or in other words, *when the two are in resonance.*

The current and therefore the amplitude of the charge of the condenser reach then their maximum value.

* It is well to observe here that later on in the analysis of more complicated circuits possessing localized self-induction and capacity, I simplify my calculations very much by substituting $L_1=-L+\frac{1}{p^2C}$ for the coeffic. of self-induction and treating the circuit then as if it had no capacity.

The resonant flow consists in a conversion of electrokinetic into electrostatic energy, and *vice versa*, during each semi-oscillation, accompanied by a loss due to ohmic resistance which is the only work which the e. m. f. does. The amplitudes of the electrokinetic and electrostatic energies must therefore be equal to each other, hence

$$\tfrac{1}{2}\,\mathrm{L}\left(\frac{\mathrm{E}}{\mathrm{R}}\right)^2 = \tfrac{1}{2}\,\mathrm{P}_\circ{}^2\,\mathrm{C}$$

where $\mathrm{P}_\circ$ = amplitude of the potential difference in the condenser.

The last relation gives, remembering that owing to resonance $p^2\mathrm{LC} = 1$,

$$\mathrm{P}_\circ = \frac{\mathrm{E}}{p\mathrm{CR}} = \frac{p\mathrm{L}}{\mathrm{R}}\,\mathrm{E} = \frac{\text{Inductance}}{\text{Resistance}} \times \mathrm{E} \qquad (8)$$

If L and p are large and R small the rise in potential can be made as large as we please, or rather as large as the condenser will stand.

The analogy between this rise of potential due to resonance and the torsional reaction of the suspension in the resonant swinging of the torsion pendulum mentioned above is striking. In both cases the reaction is produced by an accumulative effect of the impressed force.

A rough experiment only, bearing on this point and which can be easily repeated in a few minutes in every electrical laboratory, will be briefly described here.

Two large choking coils and a Marshall condenser were connected in series with the secondary of a transformer. The core of the smaller of the two choking coils consisted of a removable bundle of soft iron wire. The condenser terminals were connected to a Thomson Electrostatic Voltmeter. The frequency of the impressed e. m. f. was about 100 periods per second. The capacity of the condenser was adjusted until the removal of the plug was accompanied by bright snapping sparks, which was a signal that resonance was near. Then the removable iron core of the smaller choking coil was moved up and down gradually until the Voltmeter gave the largest deflection. A rise from 60 volts (generated in the secondary and indicated by a Cardew Voltmeter) to about 900 volts in the condenser was easily obtained. When the impressed e. m. f. was raised to 80 the condenser indicated about 1200 volts, which showed that the rise in the condenser was proportional to the impressed e. m. f., as the theory requires.* The rise of potential is practically

* I feel that it is only just to mention here that Mr. Marshall's ordinary condensers stood these voltages very well indeed, considering that they are guaranteed to stand a 1000 volts as their upper limit.

confined to the condenser, for the voltage on the line, indicated by the Cardew Voltmeter, does not change sensibly when resonance is established. *There is a large and rapid change in the current with the approach of resonance* which can be studied in a rough way by the pull which the choking coil exerts upon the removable iron core when the core is moved up and down during the process of tuning. The variation of this pull indicates very plainly that the curve expressing the relation between the current and the self-induction (resistance, capacity and frequency being constant), has a very steep crest which is in perfect accordance with the carefully plotted curve of equation (7) in Bedell and Crehore's volume on alternating currents.*

There are, however, several large maxima in this curve, each corresponding to a different capacity and self-induction; the simple experiment just described shows their presence very forcibly. The maximum corresponding to the largest capacity with about the same self-induction being however considerably the highest. With the condensers that I had at my disposal at that time I did not dare to tune the circuit for the highest maximum. The existence of several maxima will be seen presently to be a necessary consequence of the theory.

IV. *Electrical Resonance in a Circuit with a Complex Harmonic Electromotive Force.*

By Fourier's theorem a complex harmonic alternating e. m. f, can always be represented by the following series:

$$\mathrm{E} = a_1 \sin pt + a_2 \sin 2pt + \ldots\ldots a_n \sin npt \ldots\ldots$$
$$= \sum_1^{\infty} a_\alpha \sin \alpha \mathrm{pt}$$

In this expression I shall call $a_1 \sin pt$, $a_2 \sin 2\,pt$, ... the *component harmonics*, $a_1 \sin pt$ is the *fundamental harmonic*, its frequency, the *fundamental frequency*. The other harmonics will be referred to as the *upper harmonics*. The order of magnitude of their amplitudes is $a_1 > a_2 > a_3 > \ldots\ldots > a_n > \ldots\ldots$

The symbolical expression of Ohm's law is this:

$$\mathrm{L}\frac{dx}{dt} + \mathrm{R}x + \mathrm{P} = \sum_1^{\infty} a_\alpha \sin \alpha\, pt$$

Comparing this to (6) it is seen from the integral in (7) that this differential equation has the following expression for its integral:

*See Bedell and Crehore's treatise: Alternating Currents, p. 138, published by W. J. Johnston Co., New York.

$$x = \sum_{1}^{\infty}{}_{a} \frac{\alpha p C a_\alpha}{\sqrt{(1-\alpha^2 p^2 CL)^2 + \alpha^2 p^2 C^2 R}} \sin(\alpha p t - \varphi_\alpha)$$

Where $\tan \varphi_\alpha = \dfrac{1-\alpha^2 p^2 CL}{\alpha p CR}$

If we make $1-p^2CL=0$, then the *circuit is brought in resonance with the fundamental harmonic* and the current is given by

$$x = \frac{a_1}{R} \sin pt + \sum_{2}^{\infty}{}_{a} \frac{\alpha a_\alpha}{\sqrt{p^2(1-\alpha^2)^2 L^2 + \alpha^2 R^2}} \sin(\alpha p t - \varphi_\alpha).$$

If the coefficient of self-induction is large then it is perfectly evident that the amplitude of the fundamental harmonic current is by far the largest especially when the frequency of the fundamental harmonic of the impressed e. m. f. is high.

For instance, let $L = 2$, $R = 5$, $p = 2\pi \times 100$.

I select these values so as to be near the conditions under which the above experiment was performed. Under these conditions we should have for the amplitude of the next harmonic, supposing it to be an octave

$$\frac{a_2}{6\pi \times 10^2} \text{ (very nearly).}$$

The amplitude of the fundamental is therefore at least 360 times as large. In all probability this ratio is considerably larger, considering that a_1 is generally several times larger than a_2.

The higher harmonics have even much smaller amplitudes. *The rise of potential in the condenser is therefore just the same as if a simple harmonic e. m. f. of amplitude a_1 and pulsation p, acted upon the circuit.*

The tuning of the circuit produces therefore two distinct effects: 1*st*, *It produces a rise of potential in the condenser, and* 2*nd*, *It weeds out the upper harmonics.*

It may happen, however, that the circuit is tuned to one of the upper harmonics, as for instance when $\alpha^2 p^2 CL = 1$.

In this case the current is given by

$$x = \frac{a_\alpha}{R} \sin \alpha\, pt + \Sigma \frac{a_\beta}{\sqrt{(\alpha^2-\beta^2)^2 p^2 L^2 + \beta^2 R^2}} \sin(\beta p - \varphi_\beta)$$

β to take integral values from 1 to ∞ except the value α.

It is evident that now the fundamental harmonic with all the upper harmonics excepting the harmonic α is practically weeded out on account of the strengthening of the harmonic

$\frac{a_a}{R}$ *sin apt by resonance.* The rise of potential according to formula (8) is given by

$$P_a = \frac{apL}{R} a_a.$$

To show how this rise of potential compares to the rise obtained by resonance to the fundamental harmonic, let $a = 5$ and let the coefficient of self-induction be the same as before.*

$$P_1 = \frac{pL}{R} a_1$$

$$P_5 = \frac{5pL}{R} a_5$$

Hence

$$\frac{P_1}{P_5} = \frac{a}{5a_5}.$$

It is a well known fact that well made alternators are constructed in such a way that a_1 is generally larger than $5a_5$; hence, P_1 will be generally considerably larger than P_5. This was confirmed by the above experiment.

(It is well to observe that this suggests a rather interesting method of analysing a complex harmonic e. m. f. into its component harmonics *and of determining the relative value of the amplitude of each component.*)

The bearing of this on the method of producing a simple harmonic current by electrical resonance, described in the first part of this paper (l. c.) needs, I venture to say, no further discussion.

The study of resonance in electrical systems consisting of a primary and a secondary circuit with localized self-induction and capacity presents several features which deserve careful attention; a brief discussion of these together with a description of several experiments bearing upon the theory of low frequency resonance will be given in my next paper.

Electrical Engineering Laboratory, School of Mines,
Columbia College, April 15th, 1893.

[To be continued.]

* In the experiment described above the capacity was the principal variable; for, the first approximation to resonance was obtained by plugging the condenser until the vicinity of resonance was reached. The maximum point was finally obtained by a, comparatively speaking, slight variation of the coefficient of self-induction.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Properties of free Hydroxylamine.*—A further paper on the properties of hydroxylamine has been published by Lobry de Bruyn. In the solid state it forms white inodorous scales or hard needles which melt at about 33·05° and remain in the surfused state on cooling, even at 0°. At 58° and under a pressure of 23^{mm}, it boils; and when heated to 90°–100° it decomposes evolving gas. At a higher temperature it detonates. The crystals have a density of 1·35 as determined by the method of suspension in a mixture of chloroform and benzene; while in the liquid state the density is 1·23. According to Eykmann the refractive index at 14° for sodium light is 1·44123 and at 40° 1·43359. Its molecular mass by Raoult's method is 33. The crystals liquefy on exposure to air, increase in weight and volatilize completely. In a current of dry chlorine, hydroxylamine inflames; but bromine and iodine decompose it without flame. In the solid state it is oxidized on exposure to the air; a white substance is formed containing nitrous acid and ammonia. When dry oxygen is passed through the fused hydroxylamine white fumes of nitrous acid are produced with but little evolution of heat. Sodium attacks it with the production of flame. When added to its solution in dry ether, hydrogen is evolved, and a voluminous white amorphous substance is formed probably a compound of hydroxylamine with sodium hydroxylaminate. Crystals of potassium permanganate, of chromic acid, of potassium and sodium chromates and of ammonium dichromate produce decomposition with a white flame; while potassium and sodium dichromates cause a sharp violent explosion. With certain chlorides, hydroxylamine forms compounds analogous to their hydrated salt. The most probable formula the author thinks is $NH_2.OH$.—*Rec. Trav. Chim.*, xi, 18; *J. Chem. Soc.*, lxii, 1391, Dec. 1892. G. F. B.

2. *On the Trisulphide and the Pentasulphide of Boron.*—According to Moissan boron trisulphide may be formed (1) by acting on boron iodide with melted sulphur, (2) by acting on amorphous boron with the vapor of sulphur, (3) by the action of hydrogen sulphide on pure boron at a bright red heat, (4) by the action of pure carbon disulphide vapor on boron at a red heat, and (5) by the action of tin, antimony or arsenic sulphide on amorphous boron at a red heat. When condensed in a large receiver, boron trisulphide forms white slender needles which are very unstable and are decomposed by water with the evolution of hydrogen sulphide and without separation of sulphur. The crystals begin to melt at 310° and pass through a pasty condition. Their density is about 1·55. It is slightly soluble in phosphorus trichloride, from which it crystallizes in slender colorless needles.

Hydrogen does not reduce it at a red heat. It burns with a green flame in chlorine, forming boron and sulphur chlorides. Sodium and potassium decompose it below dull redness with incandescence. Water decomposes it violently, the reaction being $B_2S_3 + (H_2O)_6 = (B(OH_2))_2 + (H_2S)_3$. Ammonia combines with it to form a yellow powder, evolving great heat. Organic compounds react energetically with it.

Boron pentasulphide is a light white crystalline powder, fusing sharply at 390° and having a density of 1·85. It is best made by heating boron iodide with sulphur in a carbon disulphide solution for 24 hours at 60°. The precipitated product is washed with the disulphide to remove the iodine, with which it forms an additive compound. It is hydrolysed by water into boric acid, hydrogen sulphide and sulphur. When heated to its fusing point in a vacuum it dissociates into the trisulphide and sulphur, and is similarly decomposed when heated with mercury or silver. —*C. R.*, cxv, 203, 271; *J. Chem. Soc.*, lxii, 1393, Dec. 1892.

G. F. B.

3. *On the Oxidation of Different forms of Carbon.*—Wiesner has examined different varieties of carbon under the microscope while being subjected to the action of a mixture of sulphuric acid and potassium dichromate. Charcoal obtained by heating soot in chlorine and hydrogen successively is rapidly attacked owing to its finely divided state. Lignite consists of brown transparent particles, becoming colorless by treatment leaving a skeleton of cellulose. Anthracite, bituminous coal, wood charcoal, soot and graphite, contain a small quantity of an easily oxidizable substance which is readily dissolved by the chromic solution, leaving a residue which is only very slowly attacked. The black lung pigment acts like soot and hence must be derived from the outer air.—*Monatsb.* xiii, 371; *J. Chem. Soc.*, lxii, 1273, Nov. 1892. G. F. B.

4. *On the Rise of Salt-solutions in Filter paper.*—It was long ago observed by Schönbein that, when a piece of filter paper is immersed in a saline solution (1) the water rises more rapidly than the dissolved salt and (2) the height to which the latter rises is different for different salts. So that by this means it is possible to recognize the different constituents of a complex solution. E. Fischer and Schmidmer have investigated this phenomenon more closely and have reached the conclusion that the result is due to the differences in the diffusibilities of the dissolved substances, that salt which has the greatest velocity of diffusion rising most rapidly in the paper. Hence diffusion phenomena can be studied in this way quite as well as by the use of membranes; the new method having the advantage that it is applicable to all liquids which moisten filter paper. The authors used in their experiments a glass tube 2 cm. in diameter and 70 cm. long, containing six rolls of filter paper, each about 10 cm. long and weighing about 7 grams. The paper had been purified by washing with hydrochloric and hydrofluoric acids and the rolls

were fitted rather tightly into this tube, so as to make good contact with the walls of the tube and with each other. The tube was then placed upright in the solution to be examined, its lower end being immersed two or three centimeters deep, and it was allowed to remain in this position until the fifth roll of paper was completely moistened by the rising liquid; requiring from 3 to 4 days. To ascertain the composition of the liquids at the several levels, the tube was cut across opposite the ends of the adjoining rolls, and the rolls separately extracted with water. Using a solution containing 10 grams sodium chloride and 10 grams barium chloride in 100 c. c. water, the authors found the ratio of $BaCl_2$ to NaCl to be in the fifth roll 1 : 1·364, in the third 1 : 1·230 and in the first 1 : 1·022; showing the greater diffusibility of the sodium chloride. With a solution of 10 grams crystallized ammonium-ferrous sulphate in 100 c. c. water, 87 hours were required to reach the sixth roll, and the ratio of the Fe to the NH_3, which in the double salt is 1 : 1, was found to be in the 4th roll 1 : 1·686. When a saturated solution was used, the ratio in the fourth roll, after 96 hours, was only 1 : 1·004, and in the fifth 1 : 0·993. Potassium-ferrous sulphate and potassium-nickel sulphate gave similar results; a considerable dissociation taking place in dilute solutions, while in saturated solutions it is scarcely appreciable. Further experiments showed that aqueous solutions of the double chlorides of mercury with sodium and with lithium are decomposed by diffusion, while alcoholic solutions are not; and that the ammonium double chloride is permanent even in aqueous solution. No splitting was observed with the double salts $HNa(NH_4)PO_4(H_2O)_4$, (KCy, AgCy), and $KNaC_4H_4O_6(H_2O)_4$ in aqueous solution; but the compound of sodium chloride with grape sugar $(C_6H_{12}O_6)_2NaCl$ is partially dissociated. No decomposition was observed with naphthalene picrate or methyl-ketol picrate. Making a comparative experiment with Rüdorff's apparatus, the authors found that though the dissociation was more effective in a given time with ammonium-ferrous sulphate and with the sodium chloride compound of grape sugar by the membrane diffusion method, the filter paper method was the better for the sodium mercuric chloride.—*Ann. d. Chem.*, cclxxii, 156, 1892.

G. F. B.

5. *On Chemical Inactivity at low Temperatures.*—Some instructive experiments have been made by Raoul Pictet confirming his view that all chemical action ceases at very low temperatures. Sulphuric acid solidifying at −56° and containing 89 per cent H_2SO_4 was brought into intimate contact, in the solid condition and at a temperature −125°, with finely powdered sodium hydroxide, at the same temperature. No chemical action took place between them even when strongly compressed. Even when electric sparks were passed through the mass, no effect was produced except in the line of the sparks. On warming to −80° action suddenly began, evolving great heat and fracturing the vessel. With a weaker acid containing 35 per cent H_2SO_4

solidifying at −88°, the results were similar. In like manner potassium hydroxide remains unacted on below −90°. Concentrated ammonia and sulphuric acid do not act at all on each other below −80°; while above this temperature, a limited action takes place by means of electric sparks, complete reaction suddenly occurring at from −80° to −65°. Sulphuric acid does not react on common salt below −50°; though at about this temperature a limited reaction begins which becomes complete at −25°. No action takes place between sulphuric acid of 35 per cent and sodium or calcium carbonates at −80°. Gas bubbles make their appearance first at −56° with sodium carbonate and at −52° with calcium carbonate; the reaction becoming turbulent at −15° with the latter and at −30° with the former carbonate. With nitric acids chemical action begins at a slightly lower temperature. Metallic sodium undergoes no change when brought into contact with aqueous alcohol at −78° containing 84 per cent alcohol; the action beginning only at −48° and then being active. Sodium may be mixed with 35 per cent H_2SO_4 at −85° without any action; but at −50° a violent reaction occurs, the hydrogen taking fire. With potassium, the action begins at −68°. At −85°, sulphuric acid may be mixed with an alcoholic solution of barium chloride without precipitation, the reaction first occurring at −70° and becoming complete at −40°. An alcohol solution of silver nitrate was mixed at −125° without reaction; precipitation beginning at −90° and being complete at −80°. Potassium hydroxide dissolved in alcohol was mixed with phenol-phthaleim at −135° without action; a faint red tinge appearing at −100° and the color being distinct at −80°. Litmus in contact with acids remains blue at −120°, a sudden change to red taking place with sulphuric acid at −105° and with hydrochloric acid at −110°. Hence the author concludes that no chemical action whatever takes place at temperatures between −125° and −155°.—*C. R.* cxv, 708, 814; *J. Chem. Soc.*, lxiv, ii, 112, March, 1893. G. F. B.

6. *Berzelius und Liebig, Ihre Briefe von* 1831–1845. 279 pp., 8vo. Munich and Leipsic, 1893. (J. F. Lehmann).—The correspondence of these illustrious chemists has been well edited by Justus Carrière; it is published under the auspices of the Royal Bavarian Academy of Sciences. The book gives fascinating glimpses of the personality of both these famous men—the fire and enthusiasm of the younger Liebig and the calmer sagacity of the Northern philosopher. The letters contain much that is of historical interest to the student of chemistry, in giving many descriptions of the experiments and discoveries of both these celebrated investigators, many discussions of views and theories, and numerous criticisms of the work of other chemists of the time. The chief charm of the book, however, lies in the fact that the letters are given literally and in full, even where written in excitement and bitter animosity. These letters are supplemented by extracts from others between Liebig and Wöhler, so introduced as to give a most effective form of explanation. H. L. W.

7. *Carl Wilhelm Scheele—Briefe und Aufzeichnungen herausgegeben von* A. E. NORDENSKIÖLD. Roy. 8vo, 491 pp. Stockholm, 1892.—In thus preserving in permanent form and making public the scientific letters and laboratory notes of Scheele, Professor Nordenskiöld has rendered a great and lasting service to the historical literature of science. There seems to be a period of retrospection in chemistry at present and a desire to place its historical foundations on a sure basis, and thus the appearance of this publication is particularly opportune.

Among the crowd of eager and gifted searchers of the last half of the previous century, with whom the modern era of chemical science began, no figure stands out more luminous or conspicuous than that of Scheele. When we consider the particularly unfavorable conditions under which he worked, compared with the magnitude of the results he achieved, by the force of skill, energy and intellect, he must at once take place in the front rank of scientists of all ages. His claim to this position is materially strengthened by this publication of his notes and letters. To him must be ascribed the prior discovery of oxygen, chlorine, manganese, baryta, and many other discoveries which would have entitled a chemist to renown. Of particular importance were his researches in the line of organic chemistry, which are now for the first time fully set forth.

It is certainly true, as Professor Nordenskiöld remarks, that these letters will be read with interest and pleasure by every chemist and thinker, engaged in original research. They are chiefly addressed to Scheele's friends, Retzius, Gahn and Bergmann. Besides the notes and letters which have been carefully turned into modern German and are accompanied by critical notes, there is an able sketch of Scheele's life and facsimiles of his writings. The volume is moreover a beautiful specimen of the typographical art. L. V. P.

8. *Simple apparatus for measuring the Index of refraction of Liquids.*—H. RUOSS immerses a mirror vertically in the liquid, leaving a portion not immersed. The mirror can be turned about a vertical axis. At a suitable distance, about four meters, is placed a scale and telescope. The reflection of the scale in the air and in the liquid are then observed. One can make many observations at different angles of refraction by turning the mirror. The mean error of a single determination of index of refraction of water at 22·9° C. with sodium light was 0·00011 to 0·00005.—*Ann. der Physik und Chemie*, No. 3, 1893, pp. 531–535. J. T.

9. *Electromagnetic Theory of Color dispersion.*—H. VON HELMHOLTZ points out that no satisfactory explanation of color dispersion by the electromagnetic theory has been given. He accordingly submits the question to mathematical analysis, combining his own theories of electrically charged molecules with the general equations of Maxwell, and is led to a satisfactory explanation of the subject by means of the electromagnetic theory of light.—*Ann. der Physik und Chemie*, No. 3, 1893, pp. 389–405. J. T.

10. *Penetration of thin metallic screens by Phosphorescent rays.*—LENARD, at a recent meeting of the Berlin Academy, described some experiments upon this subject. Rays from an aluminum cathode disc were projected on a thin aluminum window 0·003^{mm} thick. The cathode rays passed through the window and made the air faintly luminous. There was a strong smell of ozone. Other gases, besides air were tried. Oxygen and carbonic acid were less penetrable than air. "One may say that hydrogen molecules cause less turbidity in the ether than those of oxygen and the latter less than those of carbonic acid."—*Nature*, March 30, 1893. J. T.

11. *Representation of Equipotential lines due to a current flowing through a metallic plate.*—E. LOMMEL, in a preliminary communication, has described a method of showing these equipotential lines. He now publishes photographs of these lines and gives an explanation of Hall's phenomenon by means of these photographs. A current of twenty ampères is passed through a thin copper plate and magnetic filings are distributed on the plate. These filings distribute themselves in the direction of the equipotential lines. If 2ε represents the potential difference between two points on the copper plate, M the strength of the magnetic field perpendicular to the direction of the current in the plate, (Hall's method), we have $2\varepsilon = KJM$, where K is a species of friction coefficient which depends upon the material of the plate employed. J is the strength of current flowing through the plate. The resistance of the plate K is proportional to its section and also to its thickness δ. Calling K a constant and r the resisttance of the galvanometer, we have

$$\varepsilon = K \cdot \frac{IM}{r\delta}$$

which expresses the law, Lommel believes, of the Hall effect.—*Ann. der Phyisk und Chemie*, No. 3, 1893, pp. 462–466. J. T.

12. *Alternating Currents: An Analytical and Graphical Treatment for Students and Engineers;* by FREDERICK BEDELL and ALBERT CUSHING CREHORE. 325 pp. 8vo. New York, 1893. (The W. J. Johnston Co.).—The subject of alternating currents is one which has come into great prominence in electrical engineering in the present time, and this fact gives especial value to a work like the one in hand, in which the whole matter is perhaps for the first time presented systematically and fully. The volume is divided into two parts; the first of which gives after some introductory statements, the solution of problems for the various cases supposed. These include circuits with resistance and self-induction, with resistance and capacity, with resistance, self-induction, and capacity; the general solution of this last case is followed by a discussion of the various cases, (1) of discharge, (2) of charge, (3) for harmonic electromotive force, and (4) for any periodic electromotive force. The latter half of the work contains the graphic treatment of a great variety of cases, which the fulness of illustrations makes very clear. The work is a very

important contribution to our knowledge of the subject, and reflects much honor upon its authors. The execution of the mechanical part of the volume by the publishers leaves nothing to be desired.

13. *Die physikalische Behandlung und die Messung hoher Temperaturen*, von CARL BARUS. 92 pp. 8vo. Leipzig, 1892. (John Ambrosius Barth–Arthur Meiner).—Dr. Barus has had rare experience in the measurements of high temperatures, and hence this general discussion of the subject, which is not only historical but also practical as based upon his own extended observations, is of very high value. The method to which he gives the preference in pyrometry is the use of the thermo-element of the platinum metals, the application of which he discusses with admirable fulness.

14. *Hülfsbuch für die Ausführung elektrischer Messungen*, von Dr. AD. HEYDWEILLER. 262 pp. 8vo. Leipzig, 1892. (Johann Ambrosius Barth–Arthur Meiner).—Brief descriptions are given in this volume of the various methods of electrical measurements, particularly those which have been introduced during the last decade or two. They include the measurements of current-strength, of resistance, capacity, and so on. Some of the most important numerical results obtained are given in the series of twenty tables at the end, and these are preceded by an extended index of authors and papers. The book brings together much valuable matter only to be found otherwise scattered through recent periodical literature.

15. *Practical Physics ;* by R. T. GLAZEBROOK and W. N. SHAW. Fourth edition, revised. 633 pp. 12mo. London and New York, 1893. (Longmans, Green & Co.).—The excellent volume on "Practical Physics" by Glazebrook and Shaw is too well known and widely appreciated to need commendation here. It has done valuable service in many physical laboratories for nearly ten years. The fourth edition now issued contains some important additions and changes, called out particularly by the experience of the authors at the Cavendish Laboratory.

16. *Elementary Treatise on Physics, Experimental and Applied*, for the use of Colleges and Schools. Translated and edited from Ganot's Éléments de Physique (with the author's sanction); by E. ATKINSON. Fourteenth edition, revised and enlarged. Illustrated by 9 colored plates and maps and 1028 woodcuts. 1115 pp. New York, 1893. (William Wood & Co.).—Thirty years have passed since the first English translation of Ganot's Physics, and in this time no less than fourteen editions have been given to the public. Perhaps no other general text book has played so important a part in the education of students in this branch of science. While appreciating its many excellent features, it is impossible not to wish that the English editor might attempt an entire re-construction of the work, so as to make it homogeneous throughout, and in accordance with the methods of the Physics of to-day.

II. Geology and Mineralogy.

1. *Additions to the Palæobotany of the Crectaceous Formation on Staten Island;* by Arthur Hollick. Trans. N. Y. Acad. Sci., vol. xii, pp. 1–12, pl. 1–iv.—Dr. Hollick adds seven new species to the flora of the Lower Cretaceous of the United States, and finds on Staten Island several of the unpublished ones of the Amboy clays described by Dr. Newberry. There can be no longer any question as to the parallelism of these two series of beds. The beautiful *Platanus Aquehongensis* here figured (pl. iv) may belong to Vitis or Grewiopsis. It is hardly a Platamus. The name *Myrica grandifolia* which he gives to the fine leaf figured on plate iii (fig. 1), is unfortunately preoccupied. It may be renamed *Myrica Hollicki*, an honor richly deserved by the discoverer.

In his effort to avoid making too many new species on insufficient material, so laudable in itself, Dr. Hollick has clearly gone too far in this paper. *Laurus primigenia* is a wide-spread Tertiary species and has never been found in the Cretaceous, except perhaps in the Laramie group. It is unlike the present figures, which are too fragmentary for safe determination. Almost the same may be said of his *Rhamnus Rossmässleri*, and Dr. Hollick is mistaken in saying that it is described by Heer from the Cretaceous of Greenland. Both these leaves have a Cretaceous aspect and differ essentially from the Tertiary species to which they are referred. Again, his claim to have discovered *Sequoia Couttsiæ* in the Cretaceous is not sustained by his figure (pl. 1, fig. 5). It is a Tertiary species, and the form here figured belongs to the older type *S. Reichenbachi.* L. F. W.

2. *On the Organization of the Fossil Plants of the Coal-Measures,* part xix; by W. C. Williamson. Phil. Trans. Roy. Soc. London, vol. clxxxiv, B, 1893, pp. 1–38, pl. i–ix.—This is one of the most important of this valuable series of memoirs. It deals entirely with *Lepidodendron Harcourtii* of Witham, originally described in 1833, subsequently treated by Lindley and Hutton and by Brongniart, and more recently by Bertrand and Hovelacque. But this is the first time that Prof. Williamson has approached the subject on account of the difficulty in finding the original types and such other material as he deemed necessary to throw any additional light upon it. Harcourt's original specimen was at length discovered in the museum at York, and much new material was supplied by the trusty collectors who have so long assisted Prof. Williamson in his researches. Although unable to prove that this species ever developed a secondary xylem, or exogenous zone, as he has shown so many Lepidodendroid forms to do in their later stages, he was still in condition to add much to what was already known of this historic plant. Perhaps the most important part of this information is that which relates to the Halonial and Ulodendroid attachments of this species. The author had shown ten years earlier from the study of other

species that the forms called Halonia were the terminal divisions of Lepidodendroid branches. This discovery is confirmed in the present case, and proof advanced that not only Halonia, but Ulodendron as well, is a state belonging to branches that either bore fruit or were destined ultimately to do so. He concludes that the Ulodendron scars were produced by the pressure of strobiles which were borne at the ends of lateral branches arrested before fairly issuing from the parent branch, and that the distinction between the Halonial and Ulodendroid condition is chiefly that in the former, owing to the presence of a short peduncle, the strobile produced no pressure disk but only a tubercular scar. All these conditions are thoroughly illustrated in the plates.

L. F. W.

3. *Fossil Plants as Tests of Climate;* by A. C. SEWARD. xii+151 pp., 8°, London, 1892.—This is the Sedgwick prize essay for the year 1892, and the award was undoubtedly a just one. Geologists usually admit the value of plants as tests of climate, whatever they may think of their value in determining age. And yet this work, which probably makes the most of this subject, shows what a difficult one it is and how unsatisfactory most of the evidence really is. We can indeed say with certainty from the existence of vegetable remains in the early Tertiary of the arctic regions, similar in their general character to those now growing in temperate climes, that a great change has taken place there since that time. This is because we are dealing with forms so well known to us that we feel that inferences based on the assumption of their similarity in respect to the effect of temperature are tolerably safe. But when we go back to Carboniferous time the force of such arguments is greatly reduced by our ignorance as to whether similarity of form implies similarity in hardiness at such widely separated periods. There are, nevertheless, many facts that indicate a much warmer climate over the whole globe in Paleozoic time than that which has since prevailed, among the strongest of which is the complete disappearance of the leading types at the close of that period, which is now generally believed to have been marked by a great fall, temporarily at least, in the general temperature. The work is chiefly a compilation of facts bearing on the problem, and the author wisely refrains from sweeping deductions. The historical sketch and discussions of distribution, temperatures, annual rings, etc., are attractive features. The literature covered shows great research. L. F. W.

4. *Flora Tertiaria Italica,* auctoribus A. MESCHINELLI and X. SQUINABOL. 1 vol., 8°, pp. lxii+578. Patavii, 1893.—This exhaustive and scholarly work has been announced some time and is highly welcome. It enumerates 1759 fossil plants, or all that are known to the authors to have been reported from any of the Tertiary deposits of Italy, and it aims to give all the information that exists relative to every such plant. That is to say, the names are followed by full bibliographical references, synonymy and brief descriptions, as well as a statement of the exact locality and

geological horizon. They are arranged in systematic order, beginning with the lowest in organization. The classification is in line with modern discovery, the Gymnosperms standing at the base of the phanerogamous series, the Monocotyledons being classed as Angiosperms coördinate with the Dicotyledons, and these latter being divided into Archichlamydæ (equal to the Apetalæ and Polypetalæ of most authors) and Sympetalæ (=Gamopetalæ), culminating in the Compositæ. In short it is substantially the classification of Engler and Prantl. The genera are also described and the species numbered for each genus. In addition to this there is a running number to all the species irrespective of genera. The systematic part is preceded by a historical sketch occupying thirty pages and giving an able review of the progress of paleophytology in Italy from the earliest times, and a complete bibliography covering 425 titles. These and other features will make this work a constant handbook for all who are engaged in the study of fossil plants. It is written wholly in Latin and is without illustrations, but the typography and general appearance are in all respects praiseworthy. L. F. W.

5. *The Correlation of Early Cretaceous Floras in Canada and the United States;* by Sir J. W. Dawson. Trans. Roy. Soc. Canada, vol. x, Section iv, pp. 79–93.—The history of our knowledge of the lower Cretaceous deposits in western North America since they were first made known by Richardson in 1872, is succinctly given in this paper as introductory to the description of certain plant remains collected by Mr. H. M. Ami and by Dr. Hayden in Canmore, Alberta, in the Kootanie district. The material was very fragmentary and the determinations are for the most part doubtful, much more so than those treated in 1885, but taken in connection with these and with the forms now known from the Great Falls of the Missouri, in Montana, referred by Newberry to the Kootanie, they help to indicate the probable nature of the vegetation of that epoch. Twenty-one distinct forms are recognized, thirteen of which are given specific names, and of these seven are referred to species occurring in the Potomac formation of Virginia. A summary of the plants of the Kootanie group is given at the end indicating those found elsewhere. The absence of Dicotyledons ("Angiosperms") thus far is taken as negative evidence that the Kootanie may be older than the Potomac, and the conclusion from the plant remains is expressed that there can "be scarcely any doubt as to their general reference to the Neocomian Group of the Lower Cretaceous, and to the lower part of the earlier or Lower Cretaceous as held by the Canadian Geological Survey." The figures in the text are very poor, and the proof reading was carelessly done, e. g. "Pagophyllum" for Pagiophyllum. L. F. W.

6. *A New Tæniopterid Fern and its Allies;* by David White. Bulletin Geol. Soc. of America, vol. iv, pp. 119–132, pl. i.—The discovery of a new species of Carboniferous fern is not usually a very important event, but in this case its relationships, as shown

by Mr. White, give the *Tæniopteris missouriensis* an especial interest from the point of view of phylogeny. It supplies a sort of "missing link" in a chain of development already pretty clearly marked out leading from the ancient Devonian Megalopteris stock through the Alethopterids and the pinnate Tæniopterids, culminating in the Jurassic Danæites and living Danæa. The present form seems to be in the direct line of descent, but there was a lateral branch of the Megalopteris stock which led through Lesquereux's American genus Lesleya and the simple forms of Tæniopteris to Fontaine's Macrotæniopteris, the most characteristic plant of the Richmond and North Carolina coal fields and Connecticut valley Trias, or Newark system. It is with this branch that the Glossopteris flora seems to have its nearest affinities in the northern hemisphere. Should these relationships ever be successfully worked out a great light will be thrown upon the geological history of plants and the early climatic conditions of the earth. The new plant was collected near Clinton, Henry county, Missouri, in the Lower Coal Measures, and if it is a Tæniopteris it is the most ancient species of that genus. The copious references given to the literature show that the author is complete master of his subject, which takes this paper entirely out of the class of mere speculations. L. F. W.

7. *The Bryozoa of the Lower Silurian in Minnesota;* by E. O. Ulrich. 4to, 332 pp., 23 plates, 1893. From vol. iii, of final Report of the Minnesota Geological Survey.—This report of the Minnesota Geological Survey by Mr. Ulrich is one of the most valuable contributions to the subject that has thus far been made. The illustrations are unsurpassed in any of the Paleontological publications of the country. The Bryozoan corals have great importance in the geology, as stated in the following paragraph from the introduction.

"The Bryozoa must be accorded the first rank among the various classes of fossils that are represented in the Lower Silurian rocks of Minnesota. They are entitled to this distinction, first, because of the great variety of form and structure among them; and, secondly, because of their exceeding abundance in the way of individuals. In both of these respects their representation exceeds that of the Brachiopoda, which doubtless held the second rank, in the approximate ratio of two to one. So plentiful are their remains in some of the beds, particularly in the shaly members, that they may be said to constitute no inconsiderable part of the strata. In the Trenton shales, the intercalated plates of limestone are literally covered with them, and they are not rare even in the massive limestones above and beneath the shales, which were deposited under conditions much less favorable to their development. In short, of every impartial collection of the Lower Silurian fossils of Minnesota, the Bryozoa necessarily constitute a large portion, not only of the number of species and specimens, but of its bulk as well.

The importance of the Bryozoa from the view of the stratigraphical geologist, is again second to no other class of fossil remains. Many of them have a wide geographical distribution, and as they usually occur in greater or less abundance, and are very persistent in their characters, their value as data upon which to base correlations of strata of widely separated localities cannot be overestimated. Many of them, especially of the suborder *Trepostomata*, are serviceable even where other fossils are too imperfect, since with the aid of thin sections, mere fractions can often be identified with certainty."

8. *The Tertiary Mollusks of Florida.*—The second part of Mr. W. H. DALL'S "Contributions to the Tertiary Fauna of Florida, with especial reference to the Miocene silex-beds of Tampa and the Pliocene beds of the Caloosahatchie river," has appeared in the transactions of the Wagner Free Institute of Science. (Vol. 3, Part II, December, 1892, pp. 201–473, with Plates 13–22).*—This part discusses the streptodont and other Gastropods. One hundred and eighteen new species are described belonging to fifty-one distinct genera. In addition to the purely descriptive portions of the work, in several cases the author has given a comprehensive review of all the species of the generic group discussed, and has commented upon the relations of the species to each other and their natural associations into subgeneric and generic groups. H. S. W.

9. *Petrographische Untersuchungen an argentinischen Graniten.* J. ROMBERG, Berlin. (N. J. M. B. B. VIII).—The material upon which this investigation has been carried out was collected by Prof. Brackebusch during his geological explorations in Argentina. Besides the descriptions of rocks the work contains a full discussion of many points of petrographical interest relating to dynamic processes. The rocks are grouped and the components treated separately with regard to special details. A description of a new mineral with an analysis on rather impure material by Jannasch is given. It seems to be between andalusite and dumortierite and is marked by a blood-red pleochroism. No name is proposed. L. V. P.

10. *Phonolite in Great Britain.*—In a brief description of some lower Carboniferons volcanic rocks of East Lowthian DR. HATCH mentions a new occurrence of phonolite, the second recorded for the British Isles, composing a hill called Traprain Law. There are also some basalts and trachytes described and a limburgite which would seem to be rather a nephelite-basalt.—*Trans. Roy. Soc. Edin.*, vol. xxxvii, pt. I, No. 8. L. V. P.

11. *Catalogue of American Localities of Minerals;* by EDWARD S. DANA. 51 pp. large 8vo. New York, 1893 (John Wiley & Sons).—Pages 1053 to 1104 of Dana's System of Mineralogy have been reprinted and issued separately for the convenience of those desiring the Catalogue of Mineral Localities in a small volume by itself.

* See this Journal, p. 351, April, 1893.

12. *Repertorium der Mineralogischen und Krystallographischen Literatur vom Anfang d. J.* 1885 *bis Anfang d. J.* 1891, *und Generalregister der Zeitschrift für Krystallographie und Mineralogie.* Band xi–xx. Herausgegeben und Bearbeitet von P. GROTH und F. GRÜNLING. I. Theil (Repertorium von P. Groth). 206 pp. 8vo. Leipzig, 1893. (Wilhelm Engelmann). —This is a very complete literature of all the mineralogical and crystallographic publications issued between 1885 and 1891. It has been prepared by Professor Groth, to whose rare industry and ability as editor we owe the twenty volumes of his "Zeitschrift," of which this marks the completion. The second part, the index of vols. xi to xx, by Dr. Grünling, is nearly ready.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Hodgkins Fund Prizes.*—The Smithsonian Institution announces the establishment of a series of prizes to be given from the income of a fund established in October, 1891, by Thomas George Hodgkins of Setauket, N. Y., "for the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man." The prizes include one of $10,000, another of $2,000, and a third of $1,000. A medal is also to be established under the name of the Hodgkins Medal of the Smithsonian Institution, in connection with the same subject. Full information in regard to the subjects for which these prizes are to be given, special conditions, etc., may be obtained from the Secretary, Professor S. P. Langley, at Washington.

2. *The Mechanics of the Earth's Atmosphere.*—A collection of translations by CLEVELAND ABBE. 324 pp. 8vo. Washington. Smithsonian Miscellaneous Collections, 843.—Professor Abbe has done a great service to meterologists, and to all interested in the physics of the atmosphere, in thus preparing and editing this valuable collection of papers. They are twenty in number, and the authors are as follows: Hagen, Helmholtz, Kirchhoff, Oberbeck, Heitz, Bezold, Rayleigh, Margules, and Ferrel.

3. *Manual of Irrigation Engineering,* by HERBERT M. WILSON. 351 pp. 8vo. New York, 1893. (John Wiley & Sons).—The subject of irrigation is one in which a large part of our country has a vital interest, and this method promises to do a great work in reclaiming land long considered of no value. This volume is a timely and comprehensive treatise on the subject, discussing the subject of precipitation and evaporation, and also very fully, the construction of dams at many points in the West. A large number of illustrations adds to its value.

4. *Jean-Servais Stas.*—Subscriptions are solicited for a fund to be used for the publication of the works of, and the erection of a monument to, the great Belgian chemist, J. S. Stas. They will be received by M. L. Errera, 1 Place Stéphanie, Brussels.